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ABSTRACT

This curriculum guide is designed to assist junior high school industrial arts teachers in planning new courses and revising existing courses in metalworking. Addressed in the individual units of the guide are the following topics: introduction to manufacturing, history and development of metalworking, safety, laboratory management, material layout, bench metal work, machine metal work, forging/heat treatment, decorative work, metal casting, sheet metal work, and career opportunities. Each unit contains some or all of the following: objectives, key words, a list of teaching aids needed, suggested references, a sentence outline, a list of materials for students, suggested student activities, student worksheets, transparency masters, student handouts, and a unit test. (MN)

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Metalworking Technology

By

Michael R. Kozak

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Editor / Barbara S. Lankes
Art Director / Ben E. Smith
Production Artists / Denise Sanderson and Laura Williams
Coordinator, Production / Barbara S. Lankes
Coordinator, Development / Jim Zukowski, Ed.D.

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Foreword

This publication is one of the new series of instructional materials for industrial arts education. It is designed to assist teachers as they plan and implement new courses of study and make revisions and improvements in existing courses. This publication is intended to help industrial arts teachers create learning environments that respond to the needs of students growing up in a complex industrial-technical society. It provides a framework that enables teachers to integrate classroom learning with real-life experiences of students.

Industrial arts is being challenged to expand and clarify its function. To meet this challenge, the industrial arts curriculum must provide opportunities for students to learn more about the technological realities in our society. This publication provides teachers with an instructional platform that focuses on industrial arts' commitment to establish its content base in the technologies.

Every effort has been made to produce a publication that addresses the unique needs of our current student population. Students with limited English proficiency (LEP) as well as handicapped, educationally disadvantaged, and nontraditional students may require modification of the material in this publication. The professional staff of EIMC will gladly work with any instructor having these students to show how the instructional material can be adapted for specific individualized instruction. Consult local, state, and federal agencies that offer assistance and guidance and that can provide sound recommendations for productive classroom management.

Kathryn R. Allen, Ph.D.
Acting Director, Extension Instruction
and Materials Center

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964: EXECUTIVE ORDERS 11246 and 11375; TITLE IX 1973 EDUCATION AMENDMENTS: REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulation by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs of activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.

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M. R. K.

Notes to the Instructor

Using the Curriculum Material

Intended Audience. The material in this curriculum package is designed for use by junior high/middle school industrial technology instructors in exploratory/introductory programs.

Length of Time for the Material. Each of the five topics of study (manufacturing, construction, plastics, metalworking, and woodworking) has been developed to provide enough material for eighteen weeks of study. Individuals who teach six-, nine-, or twelve-week classes can select parts of this curriculum material as the substance of their classes.

Emphasis of the Material. Keep in mind that this curriculum material is exploratory in nature. The emphasis is on exposing students to a wide range of experiences within the topic of study rather than on the development of technical expertise in one area.

Benefits for Instructors and Students. This material is designed to assist industrial technology instructors in the classroom as they reinforce and enhance students' skills in reading, mathematics, communications, problem solving, and social interaction. In addition, instructors who use this curriculum material will be able to help their students gain an understanding of and appreciation for management and work skills needed by individuals in the world of work. The broad exposure students receive in each topic of study will assist them in making meaningful career choices.

Flexibility of the Material. This curriculum material, like any other material, cannot encompass all situations. Therefore, instructors should feel free to supplement the material with other ideas, information, or activities as needed in their particular programs.

This material can be used in a number of different ways by industrial technology instructors. Some instructors may desire to use it as the starting point, a foundation upon which to build their own courses of study. Other instructors may prefer to teach the material as it is and add to it as they feel the need. Still other instructors may pick and choose only selected parts of this curriculum for use in their classes.

Instructors may also need to make substitutions in the curriculum depending on the equipment or references available. Other circumstances may also require instructors to make curriculum substitutions. The flexibility of this material enables instructors to use it in various ways and under various conditions. This curriculum provides instructors with an alternative in course design.

Competencies. Competencies have been identified for the topic of study. As used in this material, competencies represent skills (psychomotor), knowledge (cognitive), or attitudes (affective) that imply the ability or intelligence to accomplish a task or job. They represent the instructional intent and are stated as specific goals to be achieved. Competencies assist instructors and students in clearly formulating a purpose for learning.

Organization of the Curriculum Material

The material in each topic of study is organized into instructional units. The framework used to develop each unit consists of a number of components. These components focus on (1) outcomes, (2) materials, (3) content, (4) activities, and (5) evaluation. The components are further divided and standardized in each topic of study. An explanation of each part in the instructional unit follows.

Objectives. Objectives have been identified for each instructional unit. The objectives reflect the kind of performance necessary to successfully complete a task or job. These objectives enable a student to attain the stated competencies. Furthermore, each unit's objectives are reflected in the content, student activities, and tests for that unit.

Objectives help the instructor and the student to focus upon the important concepts to be learned in each unit. Instructors may want to duplicate the competencies and objectives and give them as handouts to the students.

Key Words: Vocabulary. New words or terms are listed to enable you to help students develop their vocabulary. Some words or terms may be listed in several units because they are used throughout a topic of study. The repetition helps reinforce vocabulary building. You will also find that each of the key words or terms appears on a student vocabulary worksheet that is included with each unit.

Teaching Aids. The materials, equipment, and supplies identified in this section will enable the instructor to plan and organize instruction better. Instructors need to review this list of teaching aids before the day of instruction since some substitutions in equipment may be needed under certain conditions. A test key has been included to help the instructor in correcting the unit test.

Each transparency in this unit is also listed. Transparency masters are provided at the end of each unit. The transparencies are keyed to a point in the sentence outline where their use is considered most appropriate. In addition to being used as transparencies, the masters may be duplicated and used as student handouts if the instructor so desires. Instructors may design or develop other transparency material that they feel enhances their instruction.

Suggested References. Many of the publications listed are available from textbook publishers. However, the reading level of these textbooks is often above junior high/middle school grade level. The materials listed in this section are suggested for use by instructors as a way to supplement their knowledge in the subject area. Instructors can review these references and use selected material as supplements to their lectures and demonstrations when appropriate. Some of the sources suggested offer free or inexpensive materials that instructors may use with their students.

Sentence Outline. The information presented in this section represents the conceptual focus of the unit. The ideas and concepts are presented in a sentence outline, as a guide from which to teach. The outline should serve as a reference from which instructors can provide instruction.

The intent was not to needlessly duplicate material that is readily available to instructors. Rather, the intent was to provide instructors with basic ideas and information that may be less accessible. The suggested references and other resources can be used by instructors to build a knowledge base from which they can synthesize relevant concepts and information. Suggested references can be used to supplement, expand, and clarify learning activities and instruction.

Materials for Students. Suggestions to instructors regarding student materials may also be listed here. Student handout materials, such as exercises, charts, graphs, puzzles, and games, are provided at the end of each unit when appropriate. These student handouts immediately follow the suggested student activities section. Handout materials may be reproduced in quantities and given to students.

Suggested Student Activities. The suggested activities are designed to reinforce and provide real applications of the concepts and content within each unit. These activities have been designed to use existing facilities and equipment, as much as possible. Another consideration was the cost factor. Suggested activities are designed to require minimum cost.

Instructors should, therefore, examine the activities and select those which are appropriate for their students. Instructors can change or modify the suggested activities if equipment, materials, and funds are not available. Instructors need to be selective in the activities they use since some activities take longer than others. Some are designed for group activity while others are for individual work. The instructor's content emphasis must also be considered. Each of the activities has been designed to reinforce and enhance basic skills that students need in everyday life.

Tests. Each unit has a multiple-choice test to assist instructors in evaluating student achievement. Multiple-choice tests provide certain advantages for instructors in evaluating the teaching-learning process. They do not capitalize on chance answers to the extent that true-false tests do. Careful development of test answers will help instructors evaluate a student's comprehension of important concepts. This also provides instructors with an easy way to assess the effectiveness of their instruction through item analysis.

Written tests are only one method of assessing learning. Instructors will also need to evaluate a student on actual performance in each activity, on abilities, and on general progress toward reaching objectives. Each instructor should develop an evaluation system that provides the most accurate assessment of a student's progress.

Instructors may prefer to develop their own test instruments. However, their test items should focus upon objectives and course content. The test for each instructional unit in this curriculum material does focus on the objectives stated at the beginning of each unit and on unit content. A test key is also provided in the teaching aids section of each unit for the instructor's use in correcting tests.

Essential Elements

I. Essential Elements Common to all Vocational Education Programs
  A. Leadership concepts and skills
    The student shall be provided opportunities to—
    1. identify characteristics and responsibilities of leaders and effective group members;
    2. participate in orderly meetings conducted according to parliamentary procedure;
    3. function effectively on committees;
    4. plan and conduct leadership activities; and
    5. prepare for effective citizenship and participation in our democratic society.
  B. Concepts and skills related to successful employment
    The student shall be provided opportunities to—
    1. develop an awareness of employment opportunities in a chosen field;
    2. practice correct procedures for job application and interview;
    3. develop the ability to take and follow both oral and written directions;
    4. practice punctuality and dependability;
    5. observe rules and standards of the workplace;
    6. demonstrate an ability to work with others harmoniously;
    7. develop responsibility and the ability to follow through on assigned tasks; and
    8. exhibit productive work habits and attitudes.
  C. Concepts and skills associated with entrepreneurship
    The student shall be provided opportunities to—
    1. recognize opportunities and options for business ownership;
    2. identify entry-level procedures, planning processes, and terms needed to open a business; and
    3. develop an understanding of the role of small business in the free enterprise system.

II. Essential Elements Common to all Industrial Arts Programs
  A. Concepts and skills in the application of safety procedures
    The student shall be provided opportunities to—
    1. demonstrate safe operation and use of selected tools and equipment to avoid injury; and
    2. maintain safe conditions in the laboratory.
  B. Concepts and skills related to planning, designing, and problem solving
    The student shall be provided opportunities to—
    1. plan and design industrial products of the student's choice;
    2. measure accurately using metric and customary units;
    3. complete itemized list of materials; and
    4. make working drawings of projects.
  C. Concepts and skills related to the tools, materials, and process of technology
    The student shall be provided opportunities to—
    1. solve industrial problems by using a variety of industrial materials;
    2. use correctly selected hand and machine tools; and
    3. select the most suitable process to complete a project.
  D. Concepts and skills related to the past, present, and future of technology
    The student shall be provided opportunities to—
    1. recognize ideas and inventions of the past and present; and
    2. relate technological change to the skills needed for the future.

E. Concepts and skills related to evaluating products and services of technology
The student shall be provided opportunities to—
1. recognize good design and construction;
2. evaluate products based on given standards or applications;
3. service industrial products and equipment; and
4. develop criteria for selecting, purchasing, and contracting services.

III. Concepts and Skills Related to Production Technology
The student shall be provided opportunities to—
A. apply industrial organization and management systems by planning, organizing, and controlling production processes;
B. apply primary industrial processes of layout, testing, separating and cutting, drilling and boring, shaping and forming, casting, laminating, coating, decorating, joining, and finishing;
C. research the recycling of industrial materials;
D. plan and implement the various steps in the construction process;
E. research the transformation of raw materials into finished products;
F. plan and implement mass production activities;
G. demonstrate techniques and processes used in automated production systems; and
H. use computers in planning, production, quality control, and management of production systems.

IV. Concepts and Skills Related to Production Technology in the Area of Manufacturing
The student shall be provided opportunities to—
A. participate in activities involving product researching, designing, and marketing;
B. investigate financial resources needed in industrial production;
C. plan and implement mass production activities;
D. apply industrial organization and management systems by planning, organizing, and controlling production processes;
E. develop production charts and graphs;
F. demonstrate an awareness of automated systems used in manufacturing;
G. recognize basic material standards and terminology used in industry;
H. apply the basic industrial processes to manufacturing;
I. research the recycling of manufactured materials; and
J. use computers in planning, production, quality control, and management of production systems.

Competencies for Metalworking

1. Know the common metals, their properties, and how they are refined.
2. Understand the principles and techniques of hand forging and a familiarity with machine forging.
3. Understand the principles and techniques of heat treatment and metallurgy.
4. Use current and evolving methods to develop orderly and effective activities in fabricating metal products.
5. Perform the common finishing methods in metalworking.

1

Introduction to Manufacturing

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. tell why we should study production technology;
2. describe manufacturing technology;
3. distinguish between primary and secondary manufacturing processes;
4. distinguish between part, subassembly, and product manufacturing;
5. give examples of current manufacturing devices;
6. identify and describe the three basic types of manufacturing: custom, continuous, and intermittent;
7. define **prototype;**
8. give examples of flexible control devices;
9. list some of the causes of pollution; and
10. list the types of pollution.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

production technology
primary manufacturing processes
custom manufacturing
intermittent manufacturing
computer numerical control
prototype
ultrasonic cutting
tracers
electrical discharge machining
pollution
manufacturing
secondary manufacturing processes
continuous manufacturing
numerical control
adaptive control
electrochemical machining
laser micromachining
electron beam machining
robotics
recycling

TEACHING AIDS

- Overhead projector
- Test Key: 1-B, 2-C, 3-A, 4-C, 5-D, 6-A, 7-B, 8-D, 9-C, 10-D, 11-A, 12-B, 13-C, 14-D, 15-A, 16-B, 17-B, 18-D, 19-A, 20-D, 21-B, 22-A, 23-D, 24-B, 25-C, 26-D, 27-A, 28-C
- Transparencies: You will find transparencies MW1-1 through MW1-15 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to the students while they are studying different aspects of this unit.

MW1-1: Industry
MW1-2: Manufacturing
MW1-3: Manufacturing Processes
MW1-4: Examples of Metalworking Processes: Forming
MW1-5: Examples of Metalworking Processes: Separating
MW1-6: Examples of Metalworking Processes: Combining
MW1-7: Laser Micromachining
MW1-8: Electron Beam Machining
MW1-9: Electrical Discharge Machining
MW1-10: Robotics

MW1-11: Flow Process Chart
MW1-12: Conventional NC System
MW1-13: Computer Numerical Control System
MW1-14: Adaptive Control System
MW1-15: Common Pollution Problems

SUGGESTED REFERENCES

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SENTENCE OUTLINE

I. Why study production technology? (Transparency MW1-1)
   A. Production technology includes the study of processes: construction and manufacturing.
   B. Production technology includes the study of materials: plastics, metals, woods.
      1. A material is a solid, liquid, or a gas out of which a thing is made.
      2. Metalworking includes the study of substances composed of metallic elements characterized by close-packed, crystal structures and a small number of valence electrons.

II. What is manufacturing?
   A. Manufacturing, as an enterprise, is a factory-based, profit-making organization. (Transparency MW1-2)
   B. Manufacturing usually includes the making of products in large quantities by hand and machine. (Transparency MW1-3)
      1. Part manufacturing produces basic components for a product.

  2. Subassembly manufacturing is the joining of two or more parts to form a portion of a product.
  3. Product manufacturing is the joining of two or more parts and/or subassemblies to produce a completed product.

 C. Primary manufacturing processes include activities that convert raw materials into industrial materials (standard stock).

 D. Secondary manufacturing processes include activities that convert standard stock into consumable products. (Transparencies MW1-4, MW1-5, MW1-6)

 E. Current manufacturing devices (examples)
  1. Electrochemical machining (ECM) uses electrical and chemical energies to act as the cutting edge of the tool.
  2. Ultrasonic cutting uses high velocity to bombard the workpiece with abrasives which machine away microscopic particles without heat.
  3. Laser micromachining is used for removal of extremely small amounts of material. (Transparency MW1-7)
  4. Tracers are used on cutting machines to produce copies of parts.
  5. Electron beam machining (EBM) cuts by alternately heating and cooling the area to be cut with emitted electrons. (Transparency MW1-8)
  6. Electrical discharge machining (EDM) removes small particles with an electric arc. (Transparency MW1-9)
  7. Robotics mixes mechanical, electrical, and computer technology. (Transparency MW1-10)
     a. Multiple arm robotics are becoming commonplace.
     b. Mobile robots are making headway into industrial applications.
     c. Many current jobs are being phased out by robots: welding, spray painting, die casting, heat treating.

III. Three basic types of manufacturing

 A. Custom manufacturing
  1. Custom manufacturing is the oldest type of manufacturing.
  2. Custom manufacturing depends on highly skilled workers who usually use simple machines and hand tools.
  3. Custom manufacturing is seldom used to produce consumer products.
  4. Specialization of skills has replaced the "broad total craftsman" who carried out the production of a product from start to finish.
  5. Custom manufacturing principles are used in building prototypes and unusual one-of-a-kind items.
     a. A prototype is anything of a certain shape, size, and quality—in which all parts work—that will be copied.
     b. Prototypes are built and tested prior to the selection of a final product design.

 B. Continuous manufacturing
  1. Continuous manufacturing is based on a constant uniform flow of parts or products from operation to operation, and is usually not stored along the line. (Transparency MW1-11)
  2. The equipment is arranged to handle the step-by-step sequence of operations by moving the material in a fixed predetermined path: elevators, conveyors, chutes, etc.
  3. Continuous manufacturing is used when large numbers of identical products are needed.

 C. Intermittent manufacturing
  1. In intermittent manufacturing, the material is moved in "lots" by forklifts, tractors, cranes, etc.
  2. Machines are grouped according to the process they perform: grinding machines together, lathes and milling machines together, etc.

    3. The majority of the parts produced across the spectrum of industries involve lots of fifty or less at a time.
        a. Used when the volume is too low to support a single production line—large products such as airplanes are not made by the thousands.
        b. Used when continuous manufacturing is not practical.
    4. Many parts, or subassemblies, used in continuous manufacturing are manufactured using intermittent techniques.
    5. Flexible control devices have resulted from intermittent manufacturing of a variety of parts in smaller quantities (10 to 1,000).
        a. Numerical control (NC)—using punch tape—became an integral part of computer-aided manufacturing during the early 1970s. (Transparency MW1-12)
        b. The microcomputer—with control information drawn from the electronic memory—allowed direct input at the machine location and is referred to as computer numerical control (CNC). (Transparency MW1-13)
        c. Adaptive control (AC)—a system that can sense variations in process variables—determines the optimum speed and feed during the actual machining and makes changes to improve or optimize the performance. (Transparency MW1-14)

IV. Manufacturing and the Environment (Transparency MW1-15)
  A. America is a victim of energy problems and environmental problems.
  B. Pollution is caused by automobiles, airplanes, home heating, hospitals, power plants, etc.
  C. The primary cause of pollution, however, is technology.
    1. We produce and utilize—nothing more is taught.
    2. Recycling must be a part of technology—waste products back into raw materials.
  D. Types of pollution
    1. Air pollution is caused basically by the combustion of materials.
    2. Water pollution is caused by the discharge of individual, municipal, industrial, and agricultural waste.
    3. Soil pollution is caused by any substance added to the soil that directly or indirectly impairs the health of animals and humans.
    4. Thermal pollution is caused by excessive heat in the environment which raises the earth's temperature.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pencil, pen, etc.
- Notebook (preferably a three-ring binder)
- Hand hacksaw, bench vises, files

SUGGESTED STUDENT ACTIVITIES

1. Begin a Metalworking Notebook. Include news clippings from the daily newspaper and/or magazines that relate to the metalworking industry. This activity should be an ongoing activity throughout the course. Include a vocabulary/key word section.
2. Begin a class metalworking bulletin board. Have students maintain and change the items on the board.
3. Arrange a field trip, or show a film that explains automation.
4. Do a time study of how individuals at school pollute the environment.
5. List several manufacturing enterprises, possibly in your city/town.

6. List several articles in your home that were manufactured.
7. What is meant by interchangeability of parts?
8. Working in small groups, have the students select one of the following activities:
   A. Product analysis
      (1) Discuss how the product was made. Examine clues such as surface appearance, weight, thickness, etc.
      (2) List primary and secondary processes that may have been used.
      (3) List various types of machines that may have been used.
      (4) Prepare a written report.
      (5) Present your findings to the class.
   B. Manufacturing devices research
      (1) Select a current manufacturing device (ECM, EBM, EDM, etc.).
      (2) Research how the device was developed, how it is being used, and how it works.
      (3) Prepare a written report.
      (4) Present your findings to the class.
   C. Flexible control devices research
      (1) Select a current flexible control device.
      (2) Research how the device was developed.
      (3) Prepare a written report.
      (4) Present your findings to the class.
   D. Recycling research
      (1) Select a common metal such as iron, gold, copper, etc.
      (2) Research how the metal is currently being recycled.
      (3) Prepare a written report.
      (4) Present your findings to the class.
9. List several reasons why a study of manufacturing could be of value.
10. List several reasons why a study of metalworking could be of value.
11. Locate examples of part manufacturing, subassembly manufacturing, and product manufacturing.
12. Using plastics, woods, and metals, list examples of standard stock.
13. Set up the manufacturing of a simple product for students to make. Prepare all jigs, fixtures, and standard stock prior to activity.
14. Have students try to work with conventional hand tools on a superhard metal. Have them record their results.
15. Have a spelling bee using the vocabulary words. Students can add to the vocabulary list from their outside reading.
16. Explain why intermittent manufacturing lends itself to a school laboratory environment.
17. Have students collect aluminum beverage cans and, as a class, visit a recycling center.

Vocabulary Worksheet

1. production technology
2. primary manufacturing processes
3. custom manufacturing
4. intermittent manufacturing
5. computer numerical control
6. prototype
7. ultrasonic cutting
8. tracers
9. electrical discharge machining
10. pollution
11. manufacturing
12. secondary manufacturing processes
13. continuous manufacturing
14. numerical control
15. adaptive control
16. electrochemical machining
17. laser micromachining
18. electron beam machining
19. robotics
20. recycling

TEST

UNIT 1: INTRODUCTION

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Production technology includes the study of--
A. energy/power and construction
B. construction and manufacturing
C. manufacturing and visual communications
D. visual communications and energy/power

___ 2. Production technology involves the study of--
A. ceramics, leather, plastics
B. plastics, wood, leather
C. plastics, metal, wood
D. ceramics, wood, metal

___ 3. A factory-based, profit-making organization is a definition for a--
A. manufacturing enterprise
B. construction company
C. production corporation
D. industrial activity

___ 4. Producing basic components for a product is--
A. subassembly manufacturing
B. primary manufacturing
C. part manufacturing
D. product manufacturing

___ 5. The joining of two or more parts and/or subassemblies to produce a completed product is--
A. subassembly manufacturing
B. primary manufacturing
C. part manufacturing
D. product manufacturing

___ 6. The joining of two or more parts to form a portion of a product is--
A. subassembly manufacturing
B. primary manufacturing
C. part manufacturing
D. product manufacturing

___ 7. Activities that convert raw materials into industrial materials are--
A. subassembly manufacturing
B. primary manufacturing
C. product manufacturing
D. secondary manufacturing

___ 8. Activities that convert standard stock into consumable products are--
A. subassembly manufacturing
B. primary manufacturing
C. product mahufacturing
D. secondary manufacturing

___ 9. A process used on cutting machines to produce copies of parts is--
A. electrochemical machining
B. electrical discharge machining
C. tracers
D. laser micromachining

___ 10. A process that bombards the workplace with abrasives is--
A. laser micromachining
B. ultrasonic cutting
C. electron beam machining
D. ultrasonic cutting

___ 11. A process that cuts by alternately heating and cooling the area to be cut is--
A. electronic beam machining
B. tracers
C. ultrasonic cutting
D. electrical discharge machining

___ 12. A process that removes small particles with an electric arc is--
A. electron beam machining
B. electrical discharge machining
C. electrochemical machining
D. tracers

___ 13. Welding, spray painting, die casting, and heat treating are current jobs being replaced by--
A. CNC
B. lasers
C. robots
D. tracers

___ 14. The oldest type of manufacturing is--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 15. A type of manufacturing that uses conveyors, elevators, etc., is--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 16. Machines are grouped according to process in--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 17. Flexible control devices are a direct result of the use of--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 18. Consumer products are seldom produced by--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 19. A type of manufacturing used when large numbers of identical products are needed is--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 20. Prototypes are mainly produced using--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 21. This is used when the volume is too low to support a single production line:
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 22. A type of manufacturing based on constant uniform flow of parts is--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 23. This is principally used in producing unusual one-of-a-kind items:
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 24. Forklifts, tractors, cranes, etc., are employed in--
A. continuous manufacturing
B. intermittent manufacturing
C. primary manufacturing
D. custom manufacturing

___ 25. A type of control that determines the optimum speed and feed during the actual machining and makes changes to improve the performance is--

A. numerical control
B. flexible numerical control
C. adaptive control
D. computer numerical control

___ 26. Direct input at the machine location is allowed in--

A. numerical control
B. flexible numerical control
C. adaptive control
D. computer numerical control

___ 27. Punch tape is used in--

A. numerical control
B. flexible numerical control
C. adaptive control
D. computer numerical control

___ 28. The primary cause of pollution is--

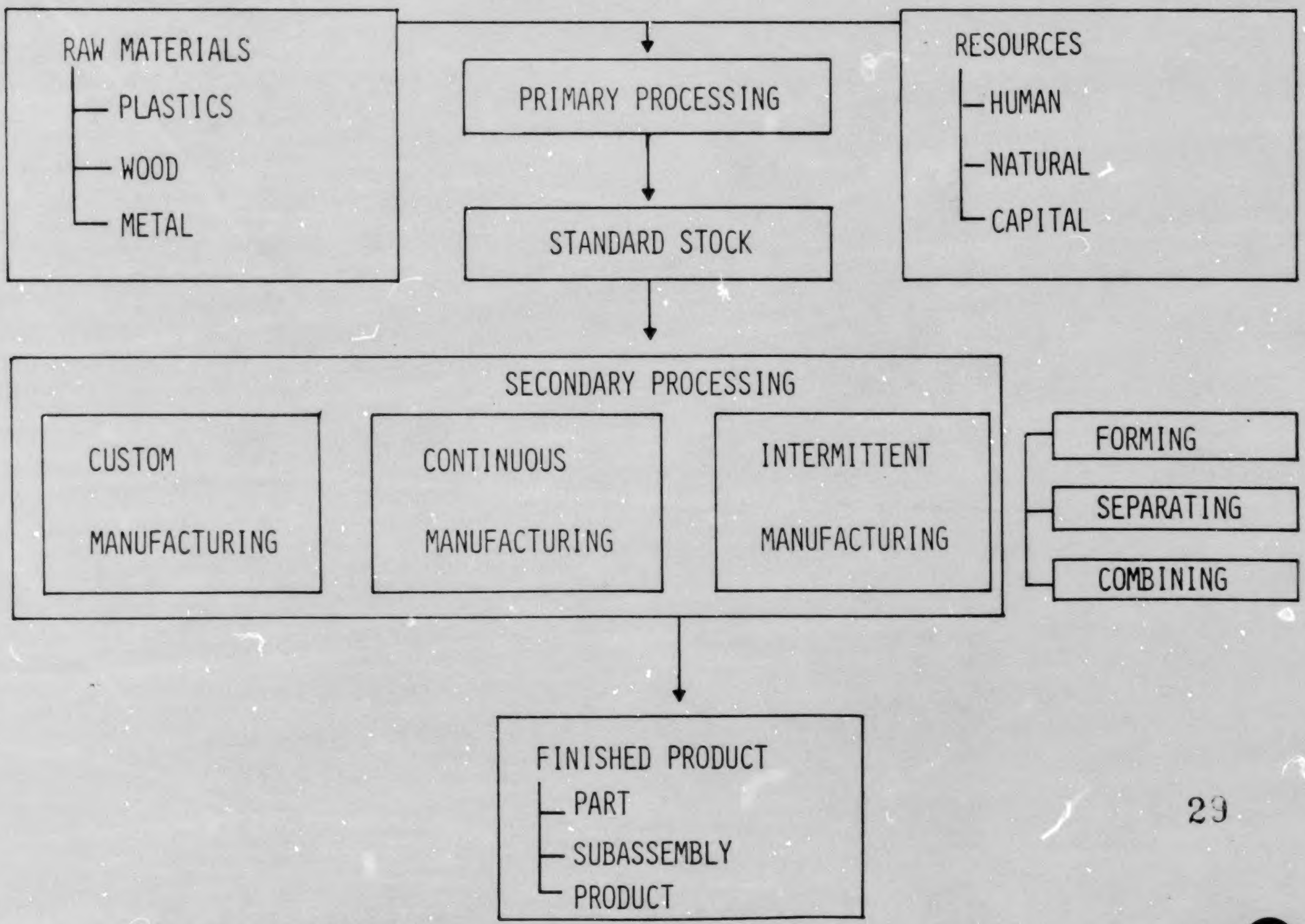
A. automobiles
B. home heating
C. technology
D. airplanes

- VISUAL COMMUNICATIONS TECHNOLOGY
  - DRAFTING
  - GRAPHIC ARTS
  - PHOTOGRAPHY
- ENERGY/POWER TECHNOLOGY
  - ENERGY
  - POWER
  - TRANSPORTATION
- PRODUCTION TECHNOLOGY
  - PROCESSES
    - CONSTRUCTION
    - MANUFACTURING
  - MATERIALS
    - PLASTICS
    - WOODS
    - METALS

INDUSTRY

MW1-2

MANUFACTURING


RAW MATERIALS
PLASTICS
WOOD
METAL
PRIMARY PROCESSING
STANDARD STOCK
RESOURCES
HUMAN
NATURAL
CAPITAL
SECONDARY PROCESSING
CUSTOM MANUFACTURING
CONTINUOUS MANUFACTURING
INTERMITTENT MANUFACTURING
FORMING
SEPARATING
COMBINING
FINISHED PRODUCT
PART
SUBASSEMBLY
PRODUCT

MANUFACTURING PROCESSES

- FORMING
  - CASTING OR MOLDING
  - COMPRESSING AND STRETCHING
  - CONDITIONING

- SEPARATING
  - SHEARING
  - CHIP REMOVING
  - OTHER

- COMBINING
  - MIXING
  - COATING
  - BONDING
  - MECHANICAL FASTENING

EXAMPLES OF METALWORKING PROCESSES

FORMING

- CASTING/MOLDING
  - SAND CASTING
  - DIE CASTING
- COMPRESSING/STRETCHING
  - BRAKE FORMING
  - ROLL FORMING
  - FORGING
  - DIE STAMPING
  - HIGH ENERGY RATE FORMING
  - SPINNING
- CONDITIONING
  - ANNEALING
  - TEMPERING
  - CASE HARDENING

EXAMPLES OF METALWORKING PROCESSES

SEPARATING

- SHEARING
    - SQUARING SHEAR
    - HOLE PUNCH
    - TIN SNIPS
    - NIBBLING
    - COLD CHISEL
- CHIP REMOVAL
    - FILING
    - TURNING
    - SHAPING
    - DRILLING
    - MILLING
    - GRINDING
- OTHER
    - ETCHING
    - OXYACETYLENE WELDING
    - ELECTRIC DISCHARGE MACHINING

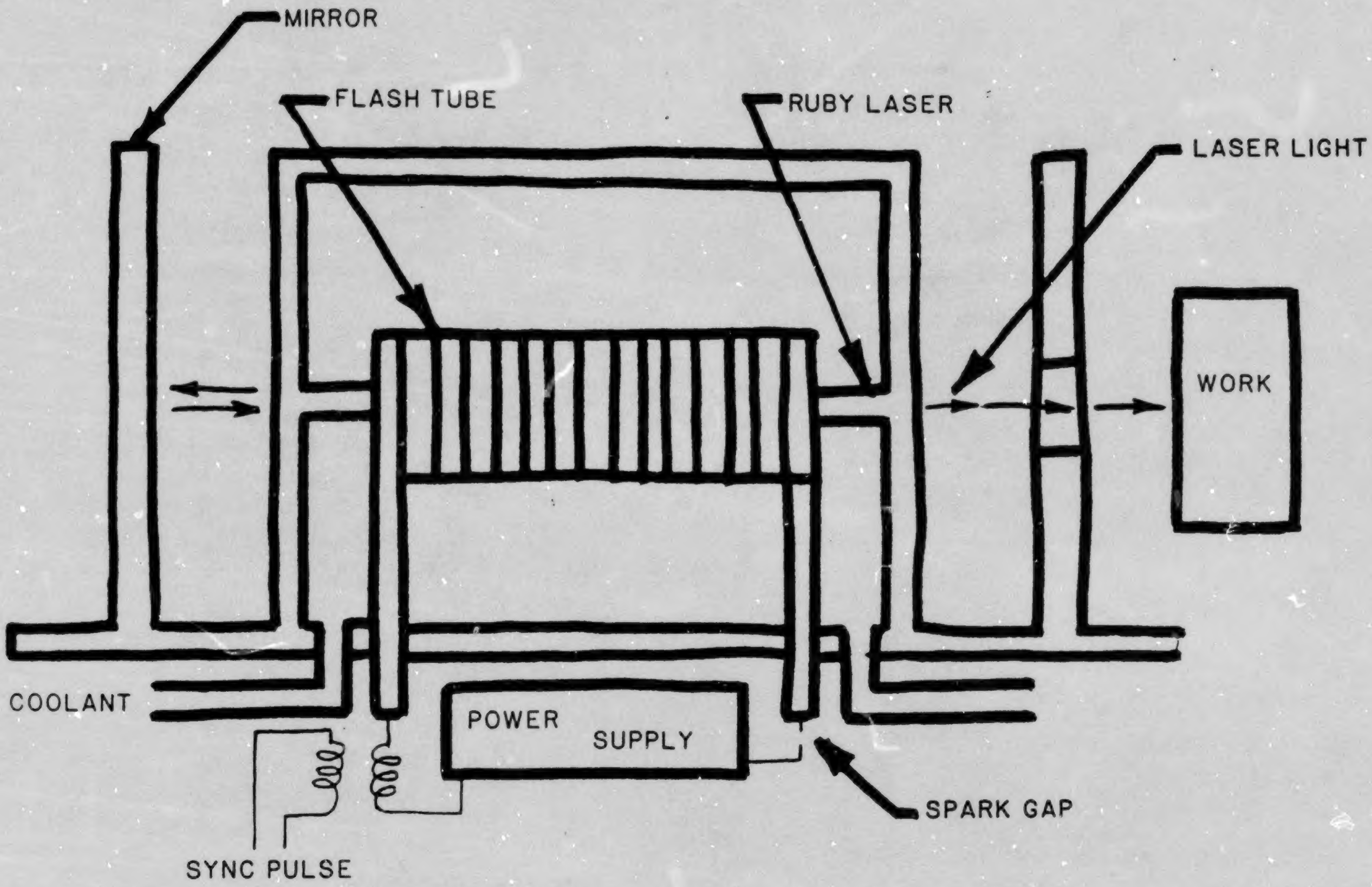
EXAMPLES OF METALWORKING PROCESSES

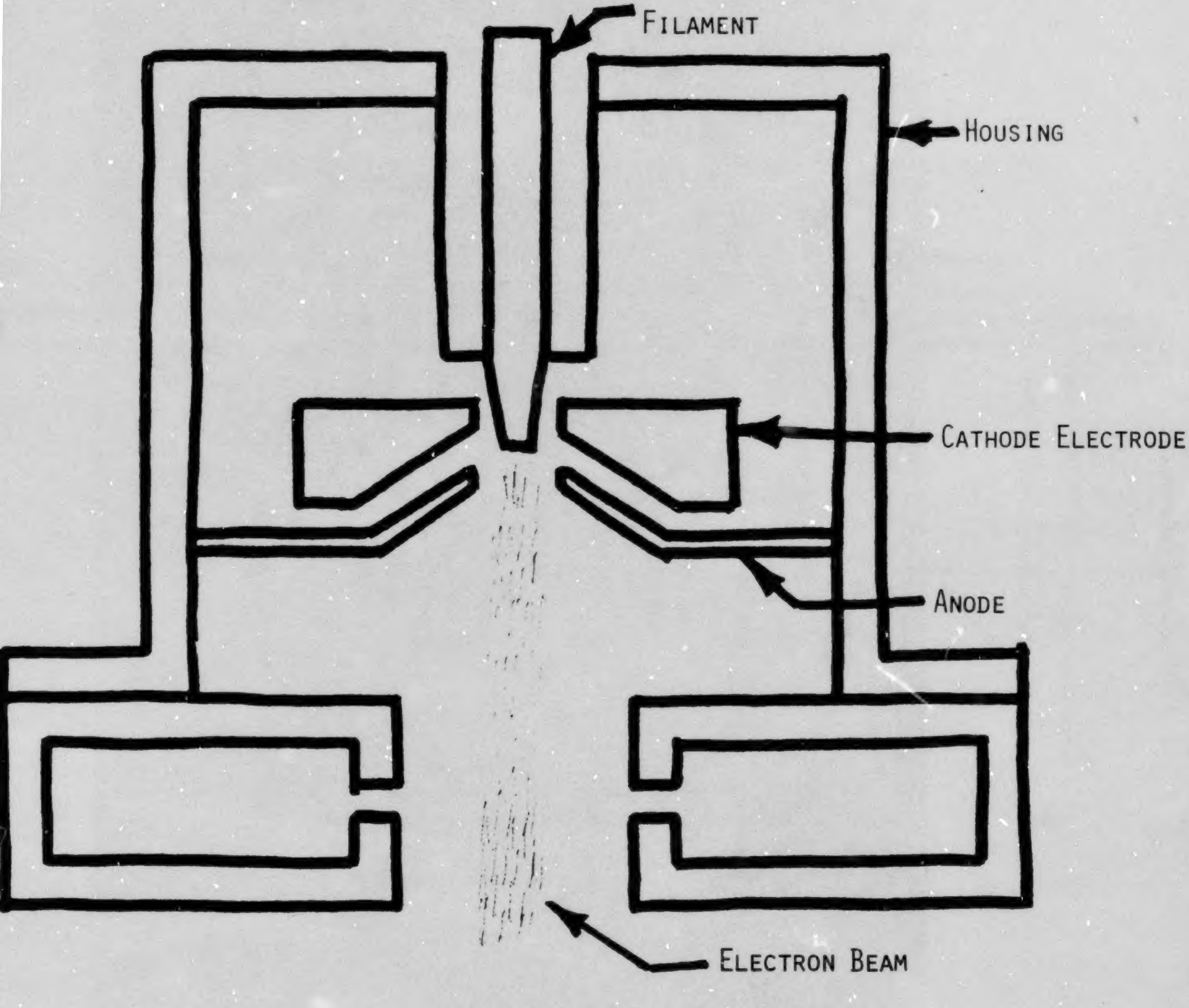
COMBINING

- MIXING
    - ALLOYING
- COATING
    - PAINTING
    - ANODIZING
    - PLATING
- BONDING
    - WELDING
    - BRAZING
    - SOLDERING
    - GLUING
- MECHANICAL FASTENING
    - RIVETING
    - TAPPING
    - THREADING

LASER MICROMACHINING

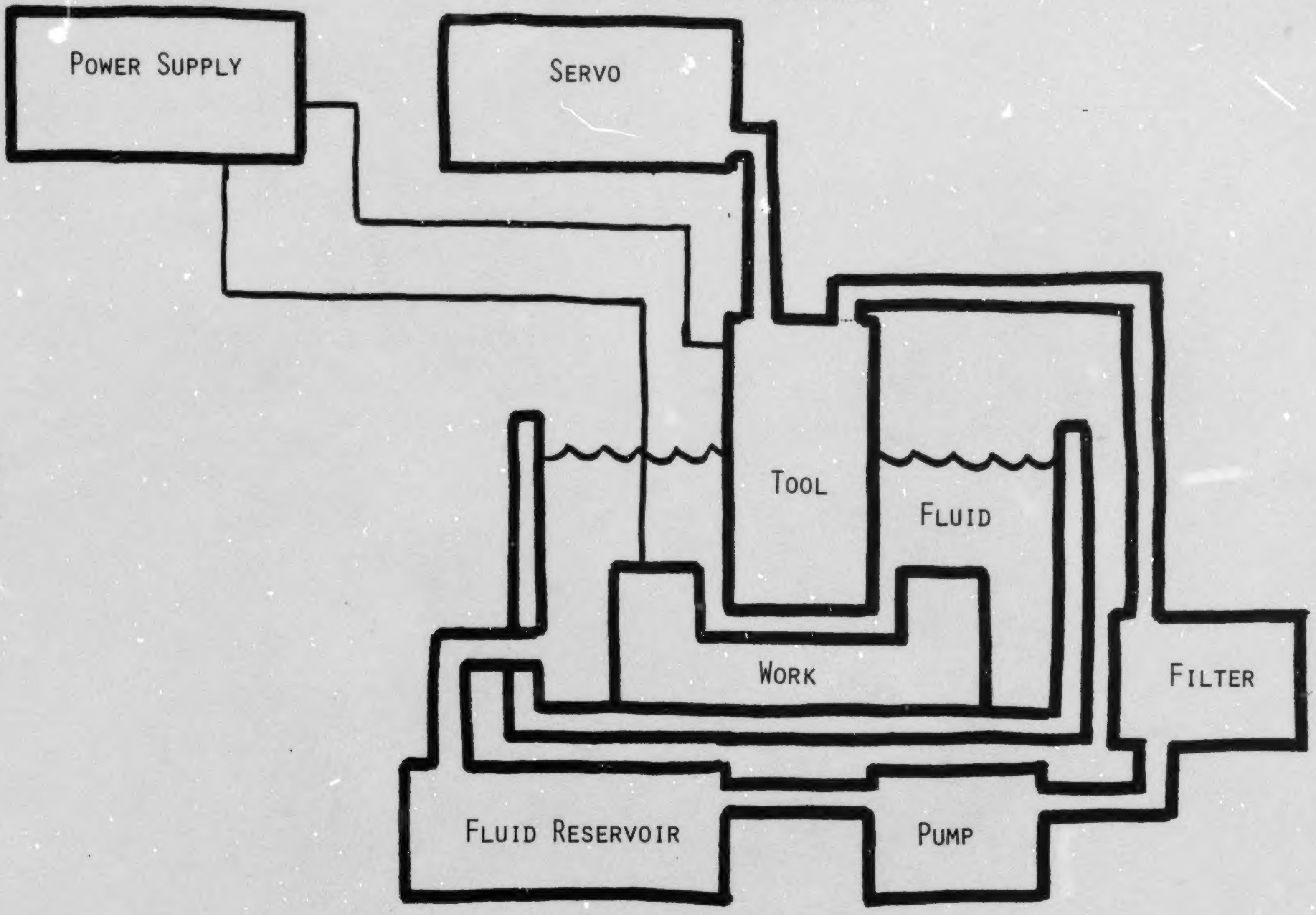
MW1-7


MIRROR
FLASH TUBE
RUBY LASER
LASER LIGHT
WORK
COOLANT
POWER SUPPLY
SPARK GAP
SYNC PULSE

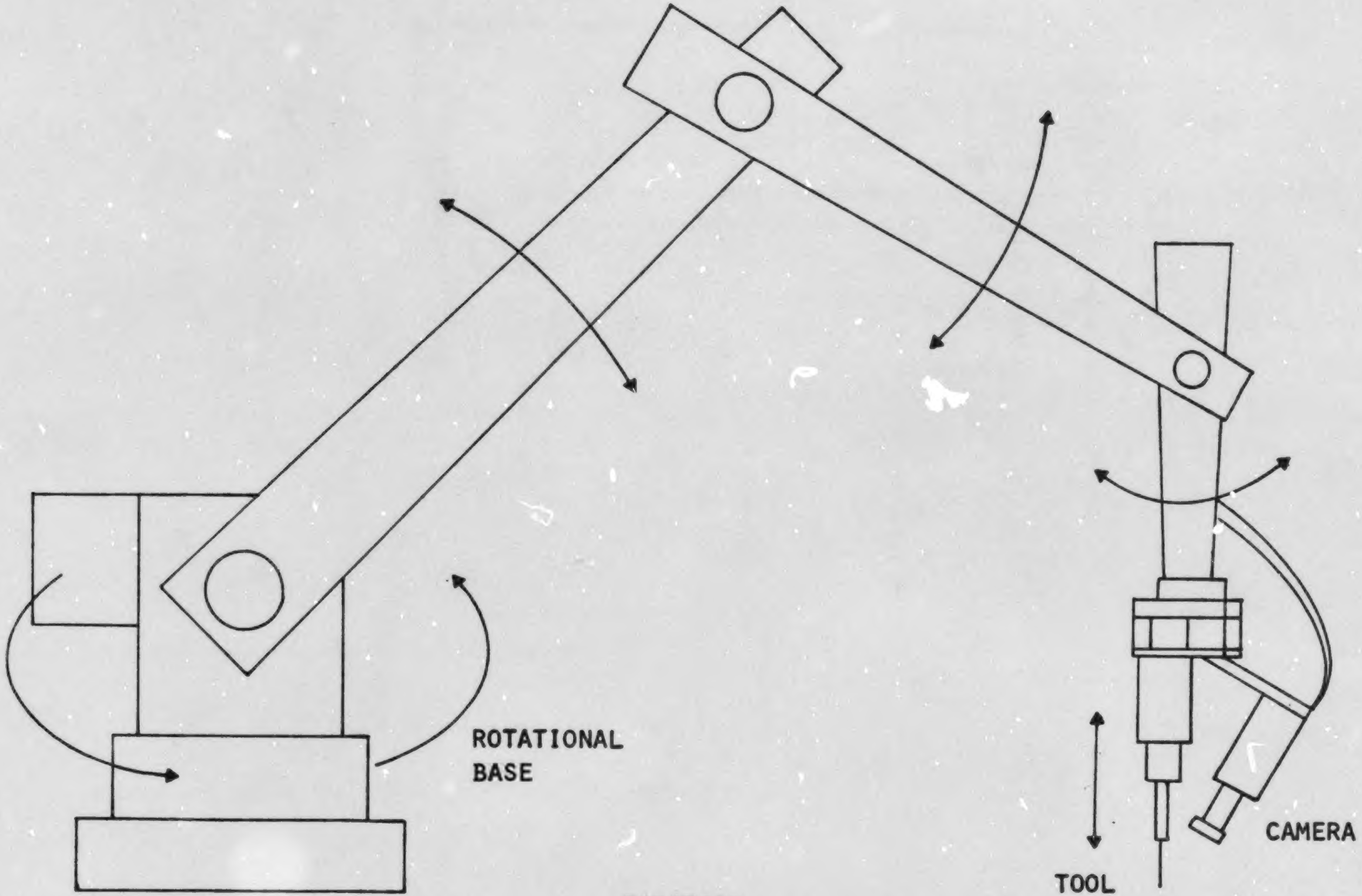

FILAMENT
HOUSING
CATHODE ELECTRODE
ANODE
ELECTRON BEAM

ELECTRON BEAM MACHINING

ELECTRICAL DISCHARGE MACHINING


POWER SUPPLY
SERVO
TOOL
FLUID
WORK
FILTER
FLUID RESERVOIR
PUMP

MW1-9


ROTATIONAL
BASE
TOOL
CAMERA

ROBOTICS

Flow Process Chart

PRODUCT NAME	*FLOW BEGINS*	*FLOW ENDS*	*DATE*

PREPARED BY: *SECTION:* *APPROVED BY:*

PROCESS SYMBOLS & NUMBER USED ○ *OPERATIONS*____ □ *INSPECTIONS*____ ⇨ *TRANSPORTATIONS*____ D *DELAYS*____ ▽ *STORAGES*____

TASK NO	*PROCESS SYMBOLS*	*DESCRIPTION OF TASK*	*MACHINE REQUIRED*	*TOOLING REQUIRED*
	○ ⇨ □ D ▽			
	○ ⇨ □ D ▽			
	○ ⇨ □ D ▽			
	○ ⇨ □ D ▽			
	○ ⇨ □ D ▽			
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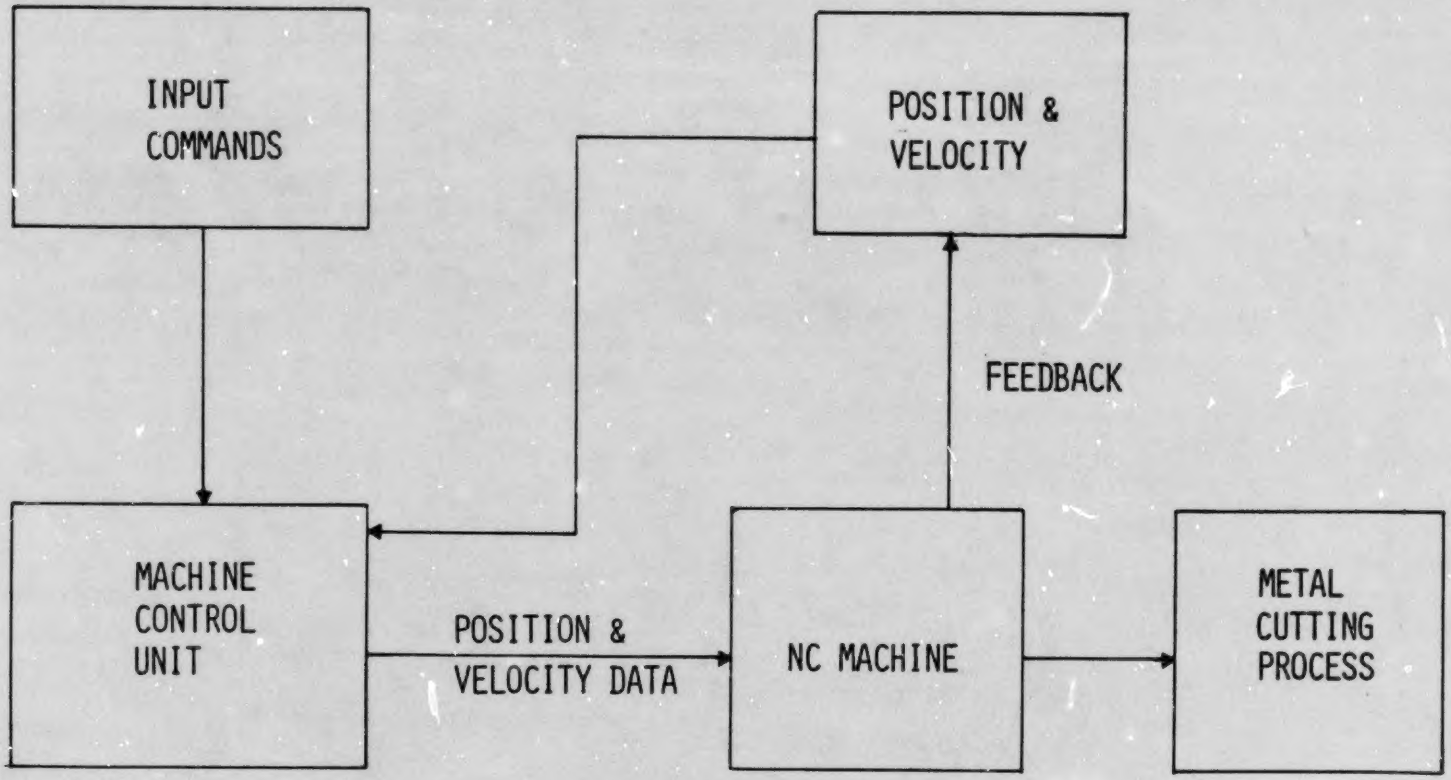
	○ ⇨ □ D ▽			
	○ ⇨ □ D ▽			

CONVENTIONAL NC SYSTEM



INPUT COMMANDS

POSITION & VELOCITY

FEEDBACK

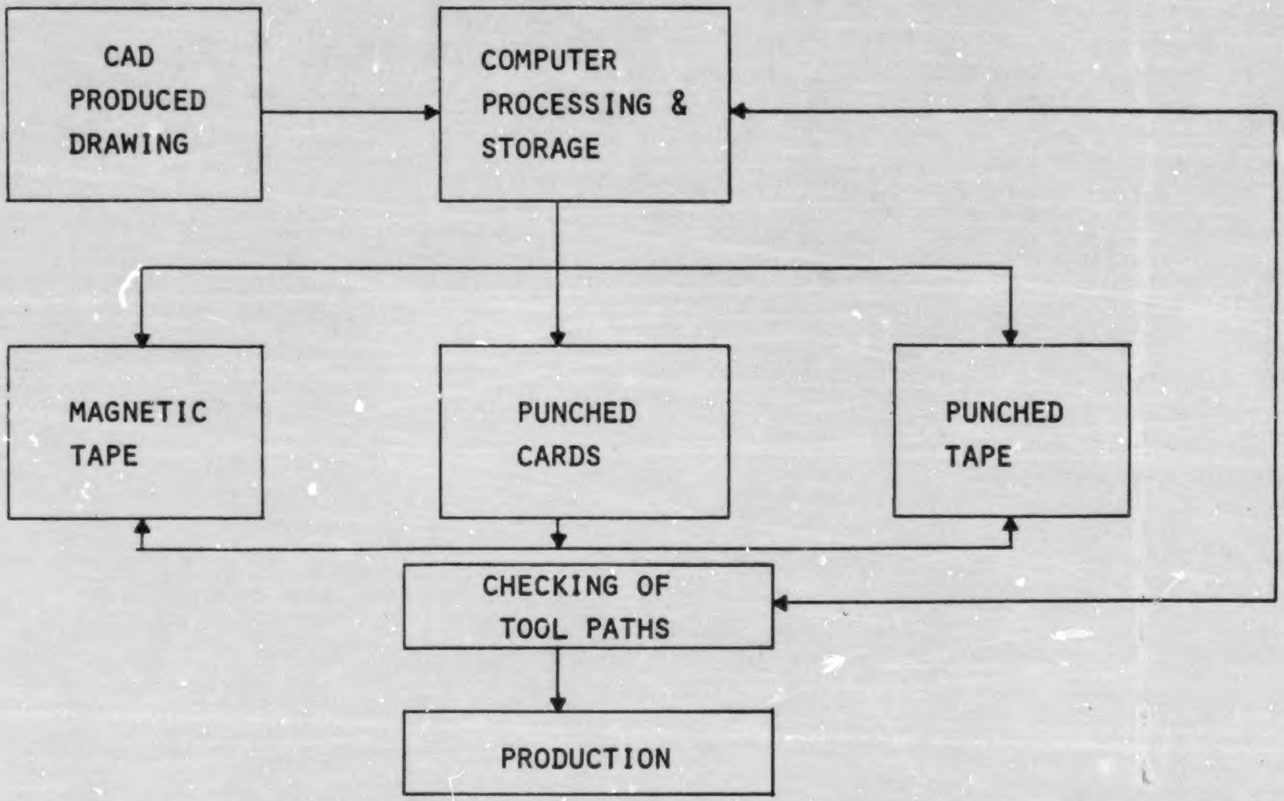
MACHINE CONTROL UNIT

POSITION & VELOCITY DATA

NC MACHINE

METAL CUTTING PROCESS

COMPUTER NUMERIC CONTROL SYSTEM



CAD PRODUCED DRAWING

COMPUTER PROCESSING & STORAGE

MAGNETIC TAPE

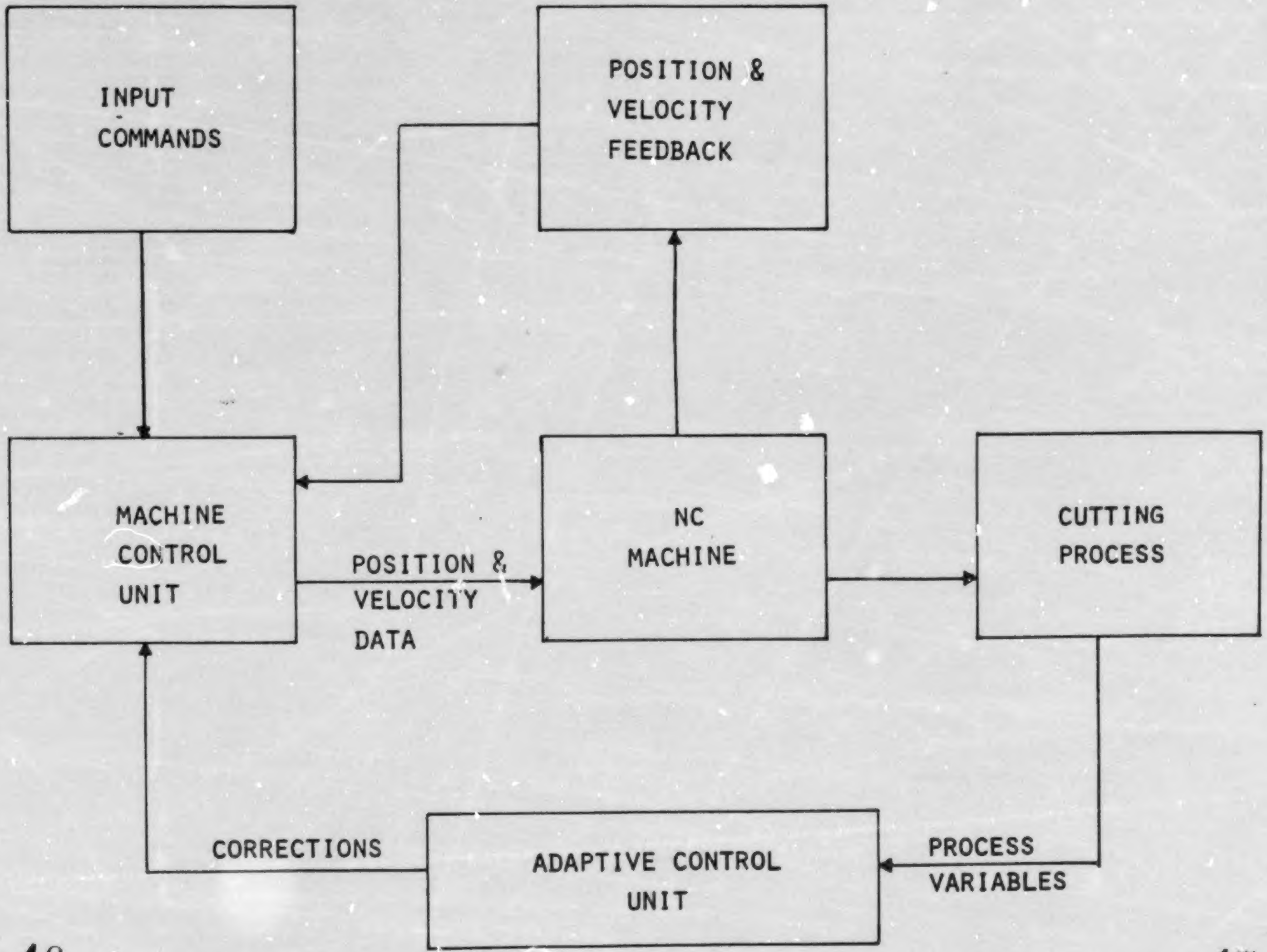
PUNCHED CARDS

PUNCHED TAPE

CHECKING OF TOOL PATHS

PRODUCTION

ADAPTIVE CONTROL SYSTEM


INPUT COMMANDS
POSITION & VELOCITY FEEDBACK
MACHINE CONTROL UNIT
POSITION & VELOCITY DATA
NC MACHINE
CUTTING PROCESS
CORRECTIONS
ADAPTIVE CONTROL UNIT
PROCESS VARIABLES

MW1-14

Common Pollution Problems

Waste disposal sites

Polluted lakes, rivers, or streams
- loss of recreation
- odors
- loss of fish
- loss of business (fishing, recreation, etc.)

Air pollution
- automobiles
- industry
- agricultural burning

Gulmination of rubbish
- disease
- flies, rats, etc.
- unsightly neighborhoods
- reduced property value

Increased noise pollution
- airports
- industry
- urbanization

2

History and Development of Metalworking

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. describe some of the historical developments related to metalworking;
2. give examples of common metals, and list their properties;
3. describe open pit mining and underground mining;
4. describe the operation of the blast furnace;
5. describe the operation of these steel-making furnaces: open hearth, basic oxygen, and electric;
6. describe the refining process for aluminum;
7. list the classifications of carbon steel, and give examples of products made from each type;
8. define alloy steel, and give examples of it;
9. list several characteristics and uses of aluminum;
10. define the principles of material selection;
11. set up and operate various types of testing equipment;
12. list and explain different testing classifications; and
13. list and explain various testing terms.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

elements
electrons
Telstar
open-pit mining
blast furnace
coke
bituminous coal
slag
basic oxygen furnace
Bessemer process
bauxite
atoms
protons
ores
underground mining
iron ore
limestone

pig iron
open hearth furnace
electric furnace
standard stock
electrolyte
ferrous
cast iron
carbon steel
angle iron
nickel
nontoxic
gold
brass
copper
tin
lead
corrosion

ASTM
static testing
destructive testing
nonferrous
wrought iron
band iron
alloy steel
chromium
aluminum oxide
aluminum
bronze
zinc
copper
galvanizing
Universal Testing Machine
dynamic testing
nondestructive testing

KEY WORDS: PEOPLE

The people listed below may be new to the student studying metalworking. Instructors should help students to understand the contributions made by these individuals to this topic of study.

Eli Whitney
William Kelly

John Deere
Joseph Glidden

Napoleon
Paul L. T. Heroult
Charles Martin Hall

KEY WORDS: PROPERTIES

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

brittleness
deformation
elasticity
malleability
specific gravity
toughness
compression
shear
conductivity
ductility
machinability
proportional limit
strength
tensile strength
hardness
impact resistance

TEACHING AIDS

- Overhead projector
- Test Key: 1-C, 2-D, 3-A, 4-C, 5-B, 6-A, 7-D, 8-C, 9-A, 10-C, 11-B, 12-B, 13-D, 14-B, 15-A, 16-C, 17-A, 18-D, 19-D, 20-A, 21-B, 22-C, 23-A, 24-B, 25-C, 26-B, 27-C, 28-D, 29-A, 30-C, 31-B, 32-D.
- Transparencies: You will find transparencies MW2-1 through MW2-17 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW2-1: Earth and the Origin of Metals
MW2-2: Typical Underground Mine
MW2-3: Blast Furnace
MW2-4: Cross Section of an Open Hearth Furnace
MW2-5: Basic Oxygen Furnace
MW2-6: Electric Furnace
MW2-7: Aluminum Refining
MW2-8: Ferrous Metals
MW2-9: Examples of Metal Shapes
MW2-10: Alloy Steel Production
MW2-11: Testing Terminology
MW2-12: Testing for Tensile Strength
MW2-13: Testing for Compression Strength
MW2-14: Testing for Hardness
MW2-15: Testing for Shear Strength
MW2-16: Testing for Impact Strength
MW2-17: An Electrical Circuit to Determine Electrical Properties

- Handouts: You will find Handouts No. 1 through No. 4 at the end of this unit. If you wish, these may be duplicated in quantity and given to students while they are studying different aspects of this unit.

Handout No. 1: Relative Conductivity of Metal
Handout No. 2: Designations of Types of Steels
Handout No. 3: 12 Major Alloying Elements of Steel
Handout No. 4: Properties of Aluminum

- Data Sheets: You will find data sheets for student laboratory experiments No. 1 through No. 6 at the end of this unit. If you wish, these may be duplicated in quantity and given to students while they are studying different aspects of this unit.

Data Sheet for Student Laboratory Experiment No. 1: Tensile Testing of Materials
Data Sheet for Student Laboratory Experiment No. 2: Compression Strength Test of Metallic Materials
Data Sheet for Student Laboratory Experiment No. 3: Hardness Testing
Data Sheet for Student Laboratory Experiment No. 4: Shear Strength Test of Metallic Materials
Data Sheet for Student Laboratory Experiment No. 5: Impact Tests of Metallic Materials
Data Sheet for Student Laboratory Experiment No. 6: Electrical Properties Test of Metallic Materials

SUGGESTED REFERENCES

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Graham, G. S. Metalworking: An Introduction. Belmont, Calif.: Breton Publishers, 1981.
Groneman, C. H., and Feirer, J. L. Getting Started in Metalworking. New York: McGraw-Hill, 1979.
Kazanas, H. C.; Klein, R. S.; and Lindbeck, J. R. Technology of Industrial Materials. Peoria, Ill. Charles A. Bennett, 1979.
Miller, R., and Morrisey, T. J. Metal Technology. New York: Howard W. Sams, 1975.
Miller, W. R., et al. Metalworking. Bloomington, Ill.: McKnight, 1978.
Walker, J. R. Modern Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.

SENTENCE OUTLINE

I. Most of the planet Earth is made up of metal. (Transparency MW2-1)
  A. Metals are chemical elements made up of atoms that contain electrons and protons.
  B. About 80 of the known chemical elements are metallic.
II. Chronology
  A. Early history
    1. In 8000 B.C., people along the Tigris and Euphrates rivers, in present-day Iraq, used copper to make tools and ornaments.
    2. In 1300 B.C., the Damascus steel sword was developed.
    3. In A.D. 500, one of the earliest power-driven, metal-cutting machines was developed (lathe).
  B. Pre-1800
    1. In 1622, America's first blast furnace was built at Falling Creek, Virginia.
    2. In 1643, the first iron industry (Company of Undertakers of the Iron Works) was established in America.
    3. In 1644, the first iron casting (The Saugus Pot) was made in America at the Saugus Iron Works, Lynn, Massachusetts.
  C. 1800s
    1. In 1818, Eli Whitney developed the milling machine.
    2. In 1827, the first iron rafters and pillars for building construction were produced.
    3. In 1837, John Deere invented the first successful steel plow.
    4. In 1847, William Kelly received the American patent for the Kelly converter to transform pig iron into steel.

5. In 1853, the first rolled wrought-iron beam was produced.
6. In 1865, the first commercial rolling of steel rail began in Chicago, Illinois.
7. In 1874, Joseph Glidden obtained a patent on barbed wire.
8. In 1876, aluminum was first used for a piece of equipment—a surveyor's transit.
9. In 1875, Napoleon's most honored guests were served with aluminum forks and spoons; lesser guests had to be content with gold and silver.
10. On February 23, 1886, Charles Martin Hall developed an electrolytic process for making aluminum. At almost exactly the same time, Paul L. T. Heroult, of Paris, France, discovered the same process. (Both men were born in 1863, and both died in 1914.)
11. In 1894, the New York, New Haven, and Hartford railroad first used aluminum in railroad application for seat frames.
12. In 1897, the Clark automobile boasted an aluminum crankcase.

D. 1900s

1. In 1906, the electric furnace was developed.
2. In 1930, the Duesenberg produced a hand-fashioned aluminum body.
3. In the 1940s, aluminum foil was introduced, and aluminum lamp bases came into use.
4. In 1952, the first aluminum-clad skyscraper opened its doors.
5. In the 1960s, the all-aluminum can began to catch on.
6. In 1961, easy-open tops for canned beverages were introduced.
7. In 1962, part of the Telstar satellite antenna contained 80,000 pounds of aluminum

III. Mining (Transparency MW2-2)

A. Gold, silver, platinum, and copper are found in their native form. Most metals, however, are combined with other elements (oxygen, sulfur, carbon) and are called ores.

B. Open-pit mining is a large "open pit" from where the exposed metal, or metal ore, is carried away to be smelted or to remove impurities.

1. In the United States, the largest supplies of iron ore are found in Minnesota, Michigan, and Wisconsin.
2. Minnesota is the principal domestic source of iron ore.

C. In underground mining, small cars carry the metal ore to a shaft to be lifted to the surface for processing.

IV. Refining

A. The first step in the production of iron is to remove the oxygen by melting the ore in a blast furnace. (Transparency MW2-3)

1. The principal materials for a blast furnace are iron ore, coke, limestone, and hot air.
   - a. Coke is the fuel used to melt and separate the iron from the ore.
   - b. Coke is made from bituminous (soft) coal by heating it to 2,100°F in a sealed oven for 18 hours.
   - c. Limestone is a dull, white rock composed of calcium carbonate that is used as a flux in refining iron.
   - d. Since iron is heavy, when the iron is in a molten state, the impurities float to the top.
   - e. During the refining process in the blast furnace, the limestone melts and forms a sticky, glasslike layer over the molten iron that absorbs the impurities from the iron.
2. The molten iron (pig iron) is tapped off one side of the blast furnace, and the slag is tapped from the other side.
   - a. Pig iron and slag are drawn from the blast furnace every 4 to 6 hours.

        - b. The pig iron from the blast furnace can be made into steel, or can be cast into products.
        - c. The slag from the blast furnace is used to make cement blocks.
- B. Steel—a form of pig iron— is produced in three major furnaces.
    - 1. Open hearth (Transparency MW2-4, Handout No. 2)
        - a. The open hearth furnace produces most of the world's steel.
        - b. The open hearth furnace is primarily used to produce carbon steel.
    - 2. Basic oxygen (Transparency MW2-5)
        - a. The basic oxygen furnace (BOF) is the newest, and currently produces one-third of the world's steel.
        - b. The BOF primarily produces carbon steel.
    - 3. Electric (Transparency MW2-6)
        - a. The electric furnace provides high temperatures very rapidly and does not require fuels to operate.
        - b. The electric furnace is used to produce special grades of steel.
    - 4. The Bessemer process of refining steel is an extinct process and is seldom, if ever, used.
    - 5. Rolling mills produce metal standard stock—sheet, strip, bar, pipe, tube, structural shape, wire, rail.
- C. Aluminum refining is a complicated process. (Transparency MW2-7)
    - 1. Aluminum ore (bauxite) is taken from open-pit mines and transported to a refining plant.
    - 2. Arkansas produces 95% of the United States output of bauxite (aluminum ore).
    - 3. Initial preparation includes crushing, drying, and screening of the bauxite.
    - 4. The production of alumina involves several steps.
        - a. Caustic soda is used to convert the bauxite into sodium aluminate.
        - b. The sodium aluminate is mixed with alumina hydrate, which yields larger amounts of alumina hydrate.
        - c. Moisture is removed through heating, which yields an alumina powder.
    - 5. The refining of alumina is the final step.
        - a. Alumina is charged (dumped) into the top of an electric furnace.
        - b. It dissolves in an electrolyte called cryolite.
        - c. The melted aluminum settles to the bottom, and the oxygen joins with the carbon from the furnace's anode to form carbon dioxide which escapes into the air.

V. Classification of metallic materials

- A. Ferrous (Transparency MW2-8)
    - 1. Products cast from pig iron are said to be made of cast iron (for example, engine blocks).
    - 2. Wrought iron is an iron that has had most of the carbon removed.
    - 3. Ninety percent of all produced steel is **carbon steel**. Carbon steels are classified as low-carbon, medium-carbon, and high-carbon steels. (Handout No. 3)
        - a. Low-carbon steels contain 0.08% to 0.35% carbon, are not hardened, are used for structural members, and can be easily welded, formed, and forged. (Transparency MW2-9)
            - (1) Low-carbon steel is used for ornamental iron work, and is usually incorrectly referred to as wrought iron.
            - (2) Band iron is low-carbon steel, varies in thickness from 1/16" to 1/4", and in widths from 3/8" to 4", and is used for braces and for reinforcing edges.
            - (3) Angle iron is low-carbon steel, varying in thickness from 1/8" to 1/2" and in widths from 1/2" to 2 1/2", and is used for braces and reinforcing of edges.

b. Medium-carbon steels are those with a carbon content between 0.35% and 0.50%, can be water hardened and tempered, can be easily welded and machined, and are used for forgings, machinery parts, and many common hand tools.

c. High-carbon steels have a carbon content over 0.55%; can be easily heat treated; are difficult to fabricate, machine, form, and weld; and are used for springs and cutting tools.

4. Ten percent of all produced steel is **alloy steel:** steel that, in addition to iron and carbon, may contain specified amounts of manganese, molybdenum, chromium, nickel, vanadium, etc. (Transparency MW2-10)
   a. Nickel is the most common alloying element in steels because it increases toughness, strength, and ductility.
   b. Chromium is the principal alloying element in stainless steel.

B. Nonferrous
1. Aluminum is the most abundant metal on earth. (Handout No. 4)
   a. Characteristics
      (1) Aluminum is silvery white in color, lightweight, strong, and rustproof.
      (2) Aluminum is nontoxic, odorless, and tasteless. It is an effective barrier to the passage of light, air, moisture, grease, and inert gases.
      (3) Aluminum is twice as conductive as copper, and it is noncorrodible.
      (4) Aluminum can withstand the terrific pressures of the deep sea as a submarine hull.
      (5) A thin layer of aluminum oxide forms on the surface of exposed aluminum and prevents further "rusting."
   b. Utilization
      (1) Aluminum powder contributes to the aerospace industry as an ingredient in solid fuels.
      (2) Eighty percent of the weight of a typical plane is aluminum.
      (3) Aluminum is strung across the nation and carries high-voltage electricity.
   c. The state of Washington leads the United States in production of aluminum, with Texas a close second.
2. Gold serves as the monetary standard of the world.
   a. Most of the gold mined in the United States is a by-product of copper mining.
   b. Gold-producing states are South Dakota, Nevada, Utah, Arizona, Washington, and Montana.
3. Brass is a copper-zinc alloy that is bright yellow in color.
4. Bronze is a copper-tin alloy that is reddish gold in color and is harder than brass.
5. Lead is bluish gray in color, heavy, soft, and has a low melting point.
6. Copper is an excellent electrical conductor, can be shaped easily, and is resistant to corrosion.
7. Zinc resists corrosion and is used as a protective coating on iron and steel (galvanizing).
8. Tin is shiny silver in color, soft, nontoxic, does not rust, and is used to coat steel for "tin cans."

VI. Principles of material selection

A. To obtain the best performance from equipment and structures, the behavior of various metals under service conditions must be known.

B. To select the correct metal or metals for a product, you must know the properties of the various metals.

C. The main purpose of metals testing is to study the behavior of the metals under specified conditions.
D. The American Society for Testing and Materials (ASTM) is responsible for the standardization of materials specifications, methods of testing, and definitions.

VII. Metals testing requires that standard procedures be followed as much as possible to assure reliability and validity.
A. The Universal Testing Machine is designed to perform tensile, compression, and bend (flexural) tests.
B. Testing classification
   1. Static testing—loads are applied and allowed to remain on the specimen for a short time.
   2. Dynamic testing—loads are applied and then immediately removed (for example, hammer blow).
   3. Destructive testing—the specimen is damaged so that it cannot be used again.
   4. Nondestructive testing—the specimen is not damaged.
C. Testing terminology (Transparency MW2-11)
   1. Brittleness is a measure of how easily the metal can crack or break suddenly.
   2. Conductivity is the rate at which a metal conducts heat or electricity. (Handout No. 1)
   3. Deformation is the dimensional change in the specimen.
   4. Ductility is the ability of a piece of metal to be stretched without breaking.
   5. Elasticity is how well the metal can be bent or twisted and then snap back to its original position.
   6. Machinability is how easily the metal can be worked with machines.
   7. Malleability is how well the metal can be hammered or worked without cracking.
   8. Proportional limit is the point beyond which the metal being tested will not return to its original shape.
   9. Specific gravity is the ratio of the weight of a given volume of a metal to the weight of an equal volume of water.
   10. Strength is the resistance of a metal to failure by deformation.
   11. Toughness is the ability of a metal to stretch without breaking.
D. Tensile and compression tests are the two most important and most commonly performed tests.
   1. Tensile strength is the strength needed to pull a specimen apart. (Transparency MW2-12)
   2. In tensile tests, the metal specimen is gripped from the two ends and pulled apart.
   3. Compressive strength is the maximum load in compression the metal can withstand before it begins to fail. (Transparency MW2-13)
   4. In compression tests, the metal specimen is compressed until it fractures, or until it goes beyond its proportional limit a specified amount.
E. Hardness is measured in terms of how much effort it takes to dent the metal. (Transparency MW2-14)
   1. Rockwell Hardness Test is the most widely used in the United States.
   2. The Brinell Hardness Test incorporates a hardened steel ball and is used for softer, porous materials.
F. The Shear Test is performed on the Universal Testing Machine, using special shear testing attachments, which causes one portion of the metal specimen to "slide" past another. (Transparency MW2-15)
G. Impact tests were developed to study the behavior of metals under dynamic loads. They are performed on notched specimens. (Transparencies MW2-16 and MW2-17)

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pencils, pens, etc.
- Notebook (preferably a three-ring binder)
- 3x5 cards
- Small pieces of copper, aluminum, steel
- Beakers
- Bunsen burner
- Weak acid solutions
- Water and salt
- Universal Testing Machine
- Metal specimens
- Calculator
- Bar magnet
- 1"x6" strip of aluminum, lead, tin, zinc, tin plate, steel, brass, bronze, copper
- Nails
- Carpet tacks
- Dry cell
- Lamp
- Socket
- Wood block
- Wire

SUGGESTED STUDENT ACTIVITIES

1. Discuss the development of civilization as related to metal (Bronze Age, Iron Age, etc.).
2. Discuss the advantages of underground mining over strip mining.
3. Discuss the safety of underground mining.
4. Research mining activities in Texas. What metal ores are commercially extracted in Texas?
5. Discuss how the core of the earth can be "mined" for its metals.
6. Discuss the effects of a blast furnace on the environment.
7. Draw a block diagram of the process of making steel.
8. In five minutes, have students list all the uses of metal they can think of.
9. Prepare a bulletin board display. Use a picture of an automobile as the center. Ask the students to identify various locations where metals are used in the car, write the information on a 3 x 5 card, and attach the card to the bulletin board.
10. Include in your "notebook" articles from newspapers and magazines that discuss space age and/or high technology metals.
11. Contact industries in your city/town, and obtain samples of products/parts made from the metals discussed in this unit.
12. Discuss the things about metals which identify them as being metallic.
13. Check your carpeting at school and/or at home. Does it have stainless steel fibers to reduce static electricity?
14. Research why gold is important to industry.
15. Demonstrate the low melting point of lead by casting some small item.
16. Discover some of the properties of copper, aluminum, and steel. Record their reaction to water, salt water, various **weak** acids, and heat.
17. Discuss which should be considered first, design or function.
18. Select a product. Determine what considerations must be made in selecting a certain metal for that product.

19. Discuss in what ways higher labor costs and higher transportation costs influence manufacturers and consumers of metal products.
20. Prepare a report on how space age research has helped develop new metals for use on the earth. Make a list of these "new" metals.
21. Explain some of the ways pollution control regulations influence the design and manufacture of metal products.
22. Discuss how high-rise buildings ruin the environment.
23. Discuss the properties of various metals.
24. Form teams of students and ask them to perform various destructive tests on metal specimens which have been prepared to correct size and shape.
25. Distinguish between ferrous and nonferrous metals by determining which of the following is attracted to a magnet:
    A. Aluminum strip
    B. Lead strip
    C. Tin strip
    D. Zinc strip
    E. Tin plate strip
    F. Steel strip
    G. Brass strip
    H. Bronze strip
    I. Copper strip
    J. Nails
    K. Carpet tacks
    L. Brads
    M. Staples
    N. Brass tacks
26. Rank strips of various metals according to their ability to conduct electrical current.

Vocabulary Worksheet

1. elements
2. electrons
3. Telstar
4. open-pit mining
5. blast furnace
6. coke
7. bituminous coal
8. slag
9. basic oxygen furnace
10. Bessemer process
11. bauxite
12. atoms
13. protons
14. ores
15. underground mining
16. iron ore
17. limestone
18. pig iron
19. open hearth furnace
20. electric furnace
21. standard stock
22. electrolyte
23. ferrous
24. cast iron
25. carbon steel
26. angle iron

27. nickel
28. nontoxic
29. gold
30. brass
31. copper
32. tin
33. lead
34. corrosion
35. ASTM
36. static testing
37. destructive testing
38. nonferrous
39. wrought iron
40. band iron
41. alloy steel
42. chromium
43. aluminum oxide
44. aluminum
45. bronze
46. zinc
47. copper
48. galvanizing
49. Universal Testing Machine
50. dynamic testing
51. nondestructive testing

People Worksheet

1. Eli Whitney
2. William Kelly
3. Napoleon
4. Paul L. T. Heroult
5. John Deere
6. Joseph Glidden
7. Charles Martin Hall

Properties Worksheet

1. brittleness
2. deformation
3. elasticity
4. malleability
5. specific gravity
6. toughness
7. compression
8. shear
9. conductivity
10. machinability
11. proportional limit
12. strength
13. tensile strength
14. hardness
15. impact resistance

TEST

UNIT 2: HISTORY AND DEVELOPMENT OF METALWORKING

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Most of the planet Earth is made up of--
A. oxygen
B. dirt
C. metal
D. water

___ 2. In 1300 B.C., the Damascus sword developed was made of--
A. iron
B. copper
C. bronze
D. steel

___ 3. Falling Creek, Virginia, was the location of America's first--
A. blast furnace
B. iron casting
C. steel producing company
D. milling machine

___ 4. The milling machine was developed by--
A. William Kelly
B. John Deere
C. Eli Whitney
D. Joseph Glidden

___ 5. The first successful steel plow was invented by--
A. William Kelly
B. John Deere
C. Eli Whitney
D. Joseph Glidden

___ 6. An American patent for transforming pig iron into steel was received by--
A. William Kelly
B. John Deere
C. Eli Whitney
D. Joseph Glidden

___ 7. Napoleon's most honored guests used utensils made from--
A. gold
B. iron
C. steel
D. aluminum

___ 8. An electrolytic process for making aluminum was developed by--
A. William Kelly
B. Eli Whitney
C. Paul L. T. Heroult
D. John Deere

___ 9. A metal not found in its native form is--
A. iron
B. gold
C. silver
D. copper

___ 10. The principal domestic source of iron ore is--
A. Arkansas
B. Texas
C. Minnesota
D. Washington

___ 11. The first step in the production of iron involves the--
A. basic oxygen furnace
B. blast furnace
C. electric furnace
D. open hearth furnace

___ 12. Coke is made from--
A. iron
B. coal
C. copper
D. limestone

___ 13. The principal materials for a blast furnace are--
A. iron ore, coke, limestone, cold air
B. iron ore, coal, limestone, hot air
C. iron ore, coal, limestone, cold air
D. iron ore, coke, limestone, hot air

___ 14. The molten iron that is tapped from the blast furnace is--
A. cast iron
B. pig iron
C. gray iron
D. wrought iron

___ 15. Not a major steel producing furnace is the--
A. Bessemer furnace
B. open hearth furnace
C. basic oxygen furnace
D. electric furnace

___ 16. Ninety-five percent (95%) of the U.S. output of aluminum ore is produced in--
A. Texas
B. Minnesota
C. Arkansas
D. Washington

___ 17. Alumina is refined into aluminum in the--
A. electric furnace
B. blast furnace
C. Bessemer furnace
D. basic oxygen furnace

___ 18. A nonferrous metal is--
A. wrought iron
B. carbon steel
C. pig iron
D. copper

___ 19. Iron that has had most of the carbon removed is--
A. pig iron
B. steel
C. cast iron
D. wrought iron

___ 20. Most ornamental iron work uses--
A. low carbon steel
B. medium carbon steel
C. high carbon steel
D. wrought iron

___ 21. The principal alloying element in stainless steel is--
A. nickel
B. chromium
C. manganese
D. molybdenum

___ 22. The most abundant metal on earth is--
A. iron
B. copper
C. aluminum
D. gold

___ 23. Although Washington leads the United States in production of aluminum, the state in second place is--
A. Texas
B. Arkansas
C. Minnesota
D. Arizona

___ 24. A copper-zinc alloy that is bright yellow in color is--
A. lead
B. brass
C. bronze
D. German silver

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___ 25. A copper-tin alloy that is reddish gold in color is--
A. lead
B. brass
C. bronze
D. German silver

___ 26. A metal used to coat iron and steel sheets in the galvanizing process is--
A. tin
B. zinc
C. brass
D. aluminum

___ 27. A testing classification in which loads are applied and then immediately removed is--
A. static testing
B. destructive testing
C. dynamic testing
D. nondestructive testing

___ 28. A measure of how easily the metal can crack or break suddenly is--
A. deformation
B. hardness
C. strength
D. brittleness

___ 29. The ability of a piece of metal to be stretched without breaking is called--
A. ductility
B. elasticity
C. machinability
D. malleability

___ 30. The strength needed to pull a specimen apart is called--
A. compression strength
B. hardness
C. tensile strength
D. shear strength

___ 31. How much effort it takes to dent the metal is a measure of--
A. compression strength
B. hardness
C. tensile strength
D. impact strength

___ 32. A study of the behavior of metals under dynamic loads, which is performed on notched specimens, is a test of--
A. compression strength
B. hardness
C. tensile strength
D. impact strength

HANDOUT NO. 1

Relative Conductivity of Metal

Material	Relative Conductivity
Silver	1.0
Copper	1.1
Aluminum	1.78
Tungsten	3.53
Iron	6.29
Lead	13.80
Mercury	60.20
Nichrome	62.90

HANDOUT NO. 2

Designations of Types of Steels

Series	Types and Percentage Composition
10XX	Nonsulfurized carbon steels
11XX	Resulfurized carbon steels (free machining)
12XX	Rephosphorized & resulfurized carbon steels (free machining)
13XX	Manganese 1.75 (principal alloy)
23XX	Nickel 3.50
25XX	Nickel 5.00
31XX	Nickel 1.25; chromium 0.65 (a binary alloy)
33XX	Nickel 3.50; chromium 1.55 (a binary alloy)
40XX	Molybdenum 0.20 or 0.25
41XX	Chromium 0.50 or 0.95; molybdenum 0.12 or 0.20
43XX	Nickel 1.80; chromium 0.50 or 0.80; molybdenum 0.25
44XX	Molybdenum 0.40
45XX	Molybdenum 0.52
46XX	Nickel 1.80; molybdenum 0.25
47XX	Nickel 1.05; chromium 0.45; molybdenum 0.20 or 0.35
48XX	Nickel 3.50; molybdenum 0.25
50XX	Chromium 0.25; 0.40 or 0.50
50XXX	Carbon 1.00; chromium 0.50
51XX	Chromium 0.80, 0.90, 0.95, or 1.00
51XXX	Carbon 1.00; chromium 1.05
52XXX	Carbon 1.00; chromium 1.45
61XX	Chromium 0.60, 0.80, or 0.95; vanadium 0.12 (0.10 to 0.15)
81XX	Nickel 0.30; chromium 0.40; molybdenum 0.12
86XX	Nickel 0.55; chromium 0.50; molybdenum 0.20
87XX	Nickel 0.55; chromium 0.50; molybdenum 0.25
88XX	Nickel 0.55; chromium 0.50; molybdenum 0.35
92XX	Manganese 0.85; silicon 2.00; chromium 0 or 0.35
93XX	Nickel 3.25; chromium 1.20; molybdenum 0.12
94XX	Nickel 0.45; chromium 0.40; molybdenum 0.12
98XX	Nickel 1.00; chromium 0.80; molybdenum 0.25

HANDOUT NO. 3

12 Major Alloying Elements of Steel

Element	Effects
Boron	Increases depth of hardness by heat treating
Chromium	Heat- and acid-resisting steels
Cobalt	High-temperature service and cutting edges
Columbium (also called Niobium)	Increases high-temperature strength
Copper	Retards rusting
Manganese	Increases strength and toughness
Molybdenum	Improved hardening qualities and resistance to shock
Nickel	Increases strength, ductility, toughness, and resistance to heat and acids
Silicon	Improves magnetic qualities
Titanium	Metallic structure control and high-temperature strength
Tungsten	Increases high-temperature hardness and strength
Vanadium	Improves heat treating and mechanical properties

HANDOUT NO. 4

Properties of Aluminum

Ease of Working	Aluminum can be fabricated economically by all the common processes.
Weight	Aluminum weighs far less than many other common industrial metals.
Tensile Strength	Some aluminum alloys have tensile strength higher than 80,000 pounds per square inch.
Corrosion Resistance	Aluminum needs no protection in most ordinary environments
Coatability	Oxide coatings of many colors and hard, wear-resisting surface finishes can be applied.
Electrical Properties	Pound for pound, aluminum has twice the conductance of copper. For equal sections, the conductivity of aluminum is 62% that of copper.
Magnetic Properties	Aluminum is nonmagnetic. Thus, electrical losses and disturbances are reduced in applications such as cable shielding and electronic equipment.
Heat Conduction	Because it transmits heat rapidly and efficiently, aluminum is widely used for kitchenware, automotive pistons, industrial equipment, and similar products.
Reflective Properties	Aluminum reflects both light and heat with high efficiency.
Low Elasticity	A low modulus of elasticity gives aluminum the ability to withstand considerable impact without deforming permanently.
Miscellaneous	Aluminum is nontoxic and odor-free; thus, it is widely used in food-processing plants and home kitchens. It is nonsparking, so it is safe near inflammable and explosive substances.

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 1

Tensile Testing of Materials

Specimen Number	Yield Strength (lbs./sq.in.)	Tensile Strength (lbs./sq.in.)	Breaking Strength (lbs./sq.in.)	Elongation (percent)	Reduction of Area (percent)

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 2

Compression Strength Test of Metallic Materials

Specimen Material	Yield Load (psi)	Original Diameter	Original Area (in^2)	Final Area (in^2)	Percentage Deformation (%)
Aluminum					
Brass					
Steel					

Formulas

(a) Area (A) = πr^2

(b) Percentage Deformation = $\frac{\text{Final Diameter}}{\text{Original Diameter}} \times 100$

(c) Yield Strength = $\frac{\text{Yield Load}}{\text{Original Area}} \quad (A_o)$

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 3

Hardness Testing

__________TYPE HARDNESS TESTER

Specimen Number	Type of Material	Hardness Scale	Readings			Average
			1	2	3	

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 4

Shear Strength Test of Metallic Materials

Material	Maximum Load				Specimen Diameter	Area	Shear Strength
	1	2	3	Average			
Aluminum							
Brass							
Steel							

Formulas

(a) Area (A) = πr^2

(b) Shear Strength (S) = $\left(\frac{\text{Average Maximum Load}}{\text{Area}}\right) \div 2$

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 5

Impact Tests of Metallic Materials

Specimen Number	Specimen Dimensions (mm)	Absorbed Energy (ft. lbs.)	Type of Surface at the Break

DATA SHEET FOR STUDENT LABORATORY EXPERIMENT NO. 6

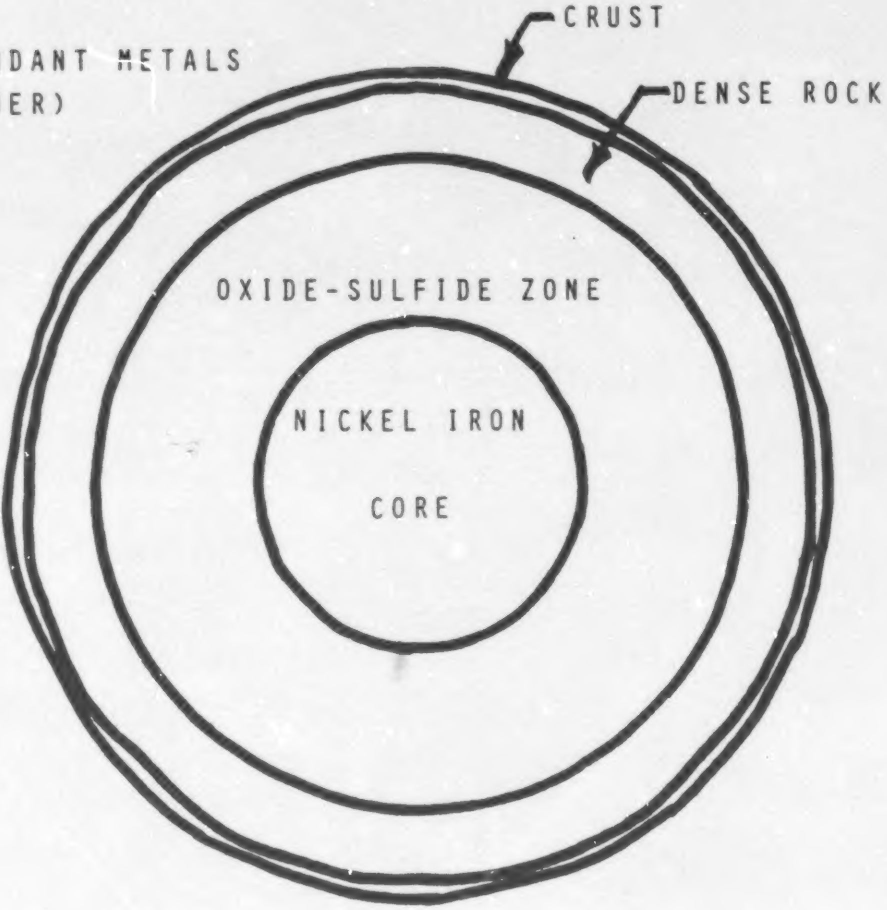
Electrical Properties Test of Metallic Materials

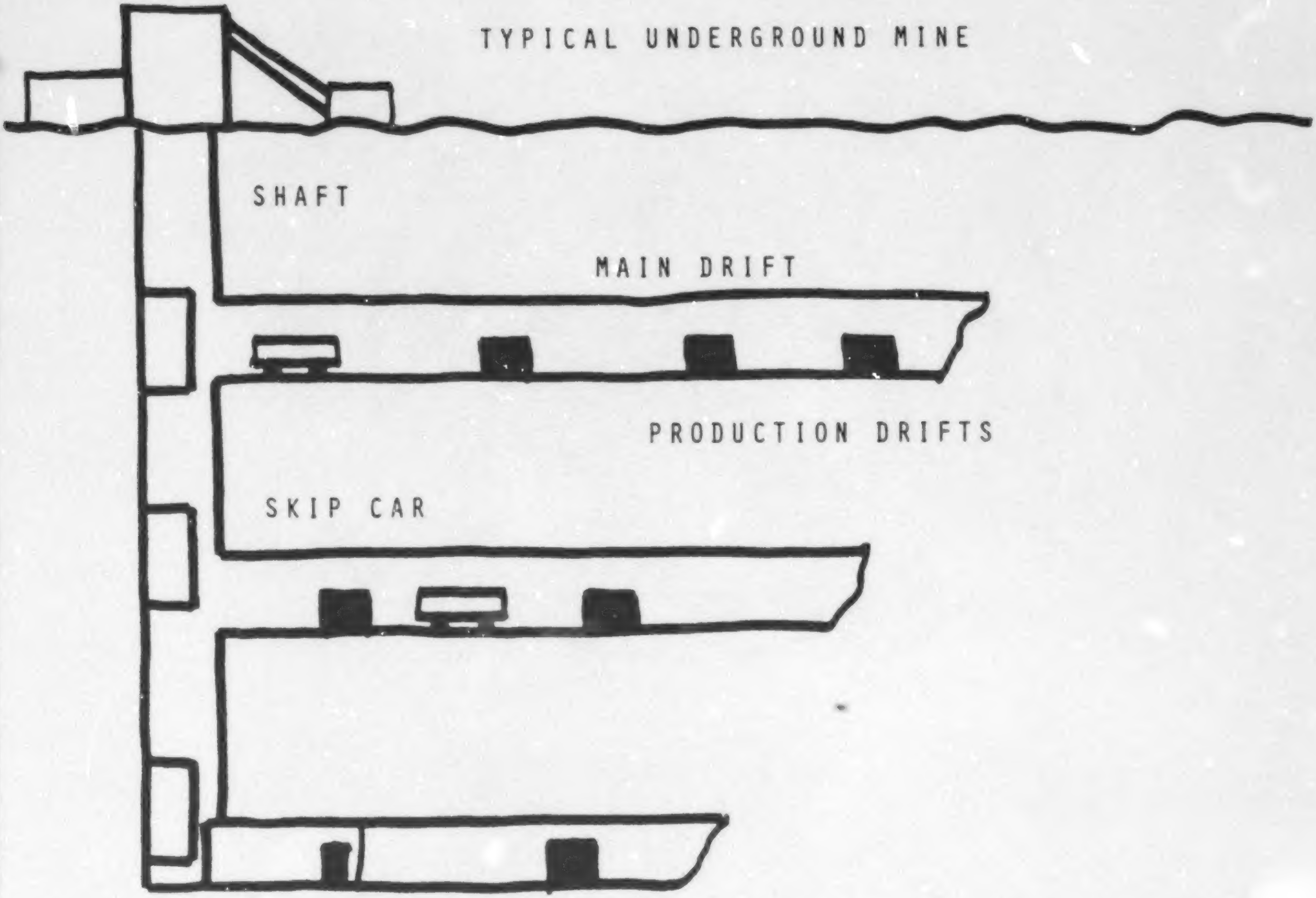
Specimen Material	Bulb lights brightly	Bulb glows dimly	Bulb does not light	Ranking of specimens
Aluminum				
Brass				
Bronze				
Copper				
Lead				
Steel				
Tin				
Tin Plate				
Zinc				

EARTH AND THE ORIGIN OF METALS

15 MOST ABUNDANT METALS
(IN RANK ORDER)

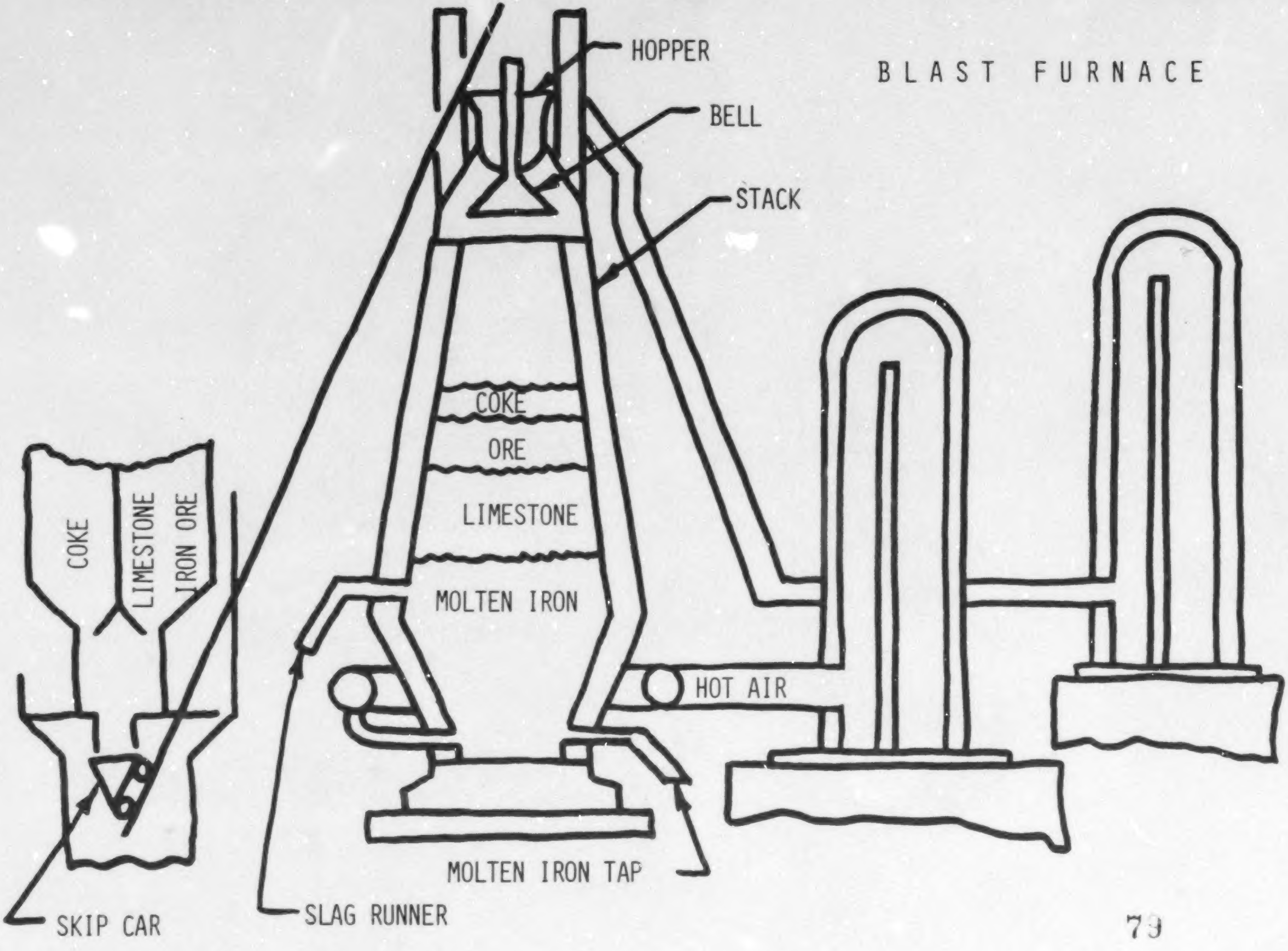
- ALUMINUM
- IRON
- MAGNESIUM
- TITANIUM
- MANGANESE
- CHROMIUM
- ZIRCONIUM
- NICKEL
- VANADIUM
- COPPER
- TUNGSTEN
- ZINC
- LEAD
- MOLYBDENUM
- TIN


CRUST
DENSE ROCK
OXIDE-SULFIDE ZONE
NICKEL IRON
CORE


TYPICAL UNDERGROUND MINE
SHAFT
MAIN DRIFT
PRODUCTION DRIFTS
SKIP CAR

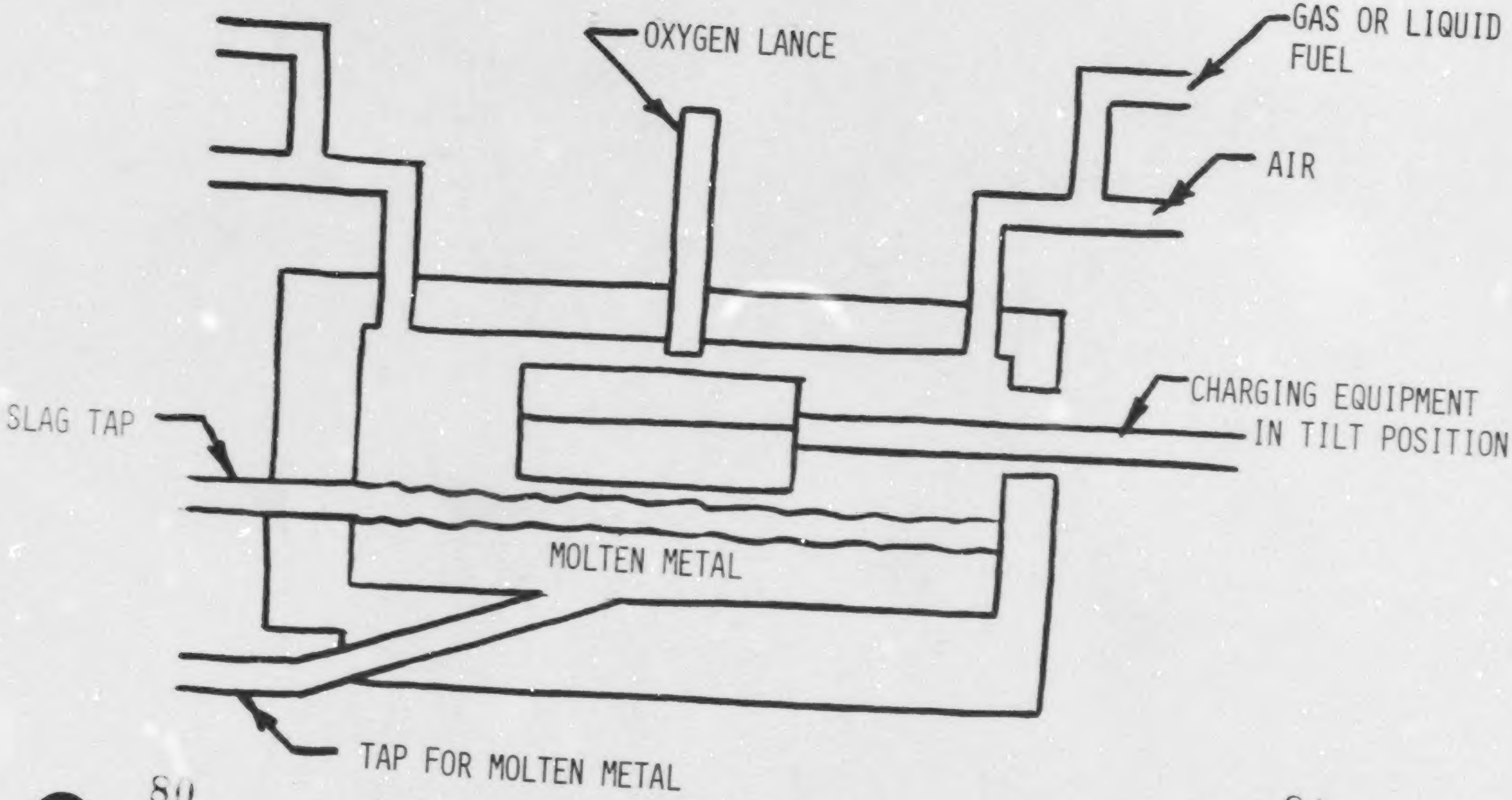
BLAST FURNACE

MW2-3


HOPPER
BELL
STACK
COKE
ORE
LIMESTONE
MOLTEN IRON
COKE
LIMESTONE
IRON ORE
HOT AIR
MOLTEN IRON TAP
SLAG RUNNER
SKIP CAR

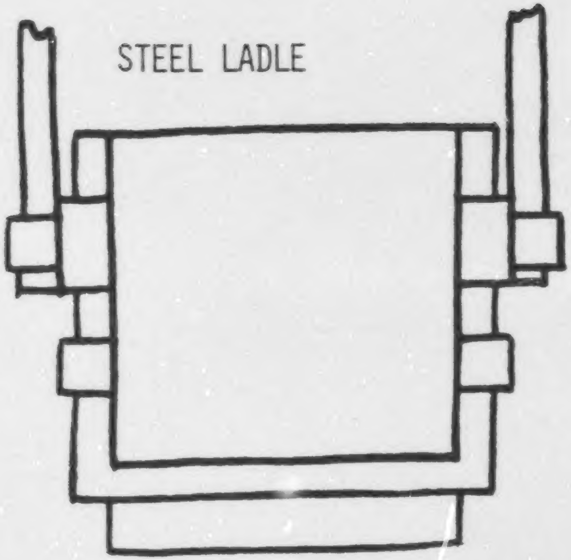
MW2-4

CROSS SECTION OF AN OPEN HEARTH FURNACE

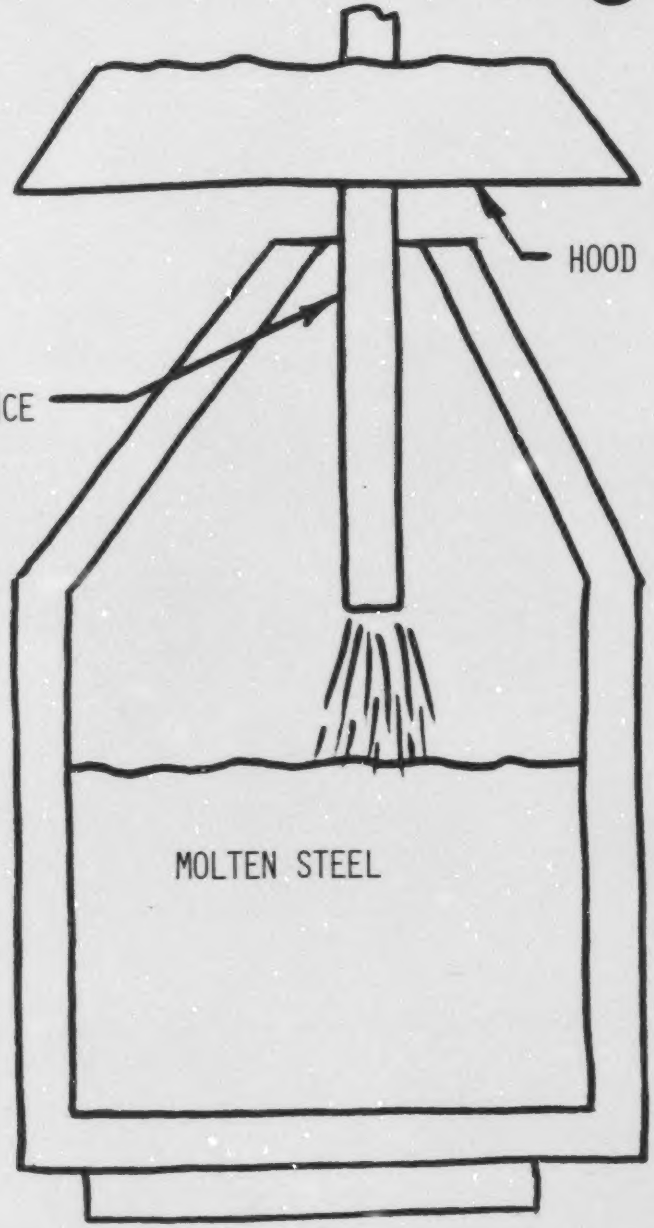

OXYGEN LANCE
GAS OR LIQUID FUEL
AIR
CHARGING EQUIPMENT IN TILT POSITION
SLAG TAP
MOLTEN METAL
TAP FOR MOLTEN METAL

BASIC OXYGEN FURNACE

MW2-5


STEEL LADLE

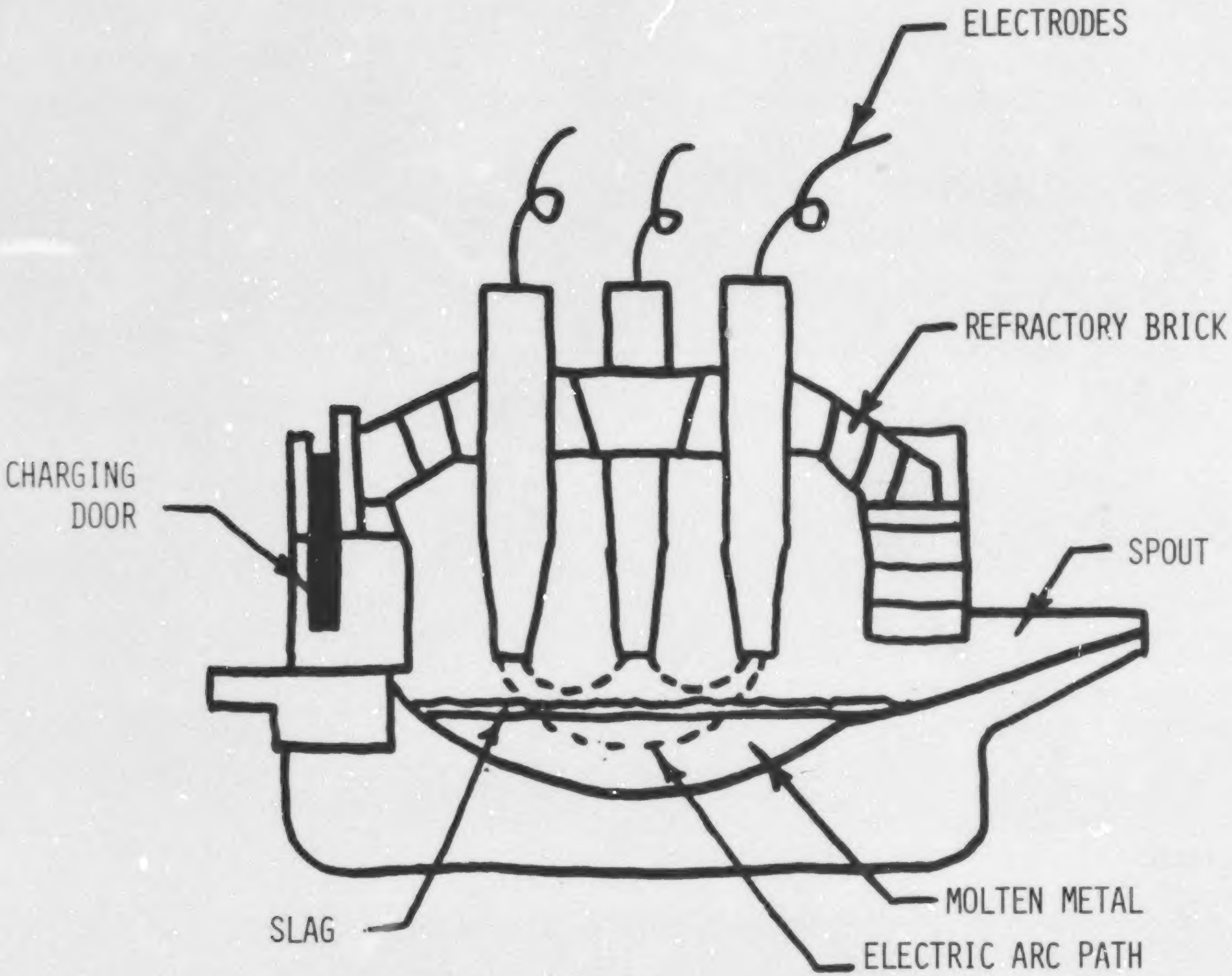
82


HOOD
OXYGEN LANCE
MOLTEN STEEL

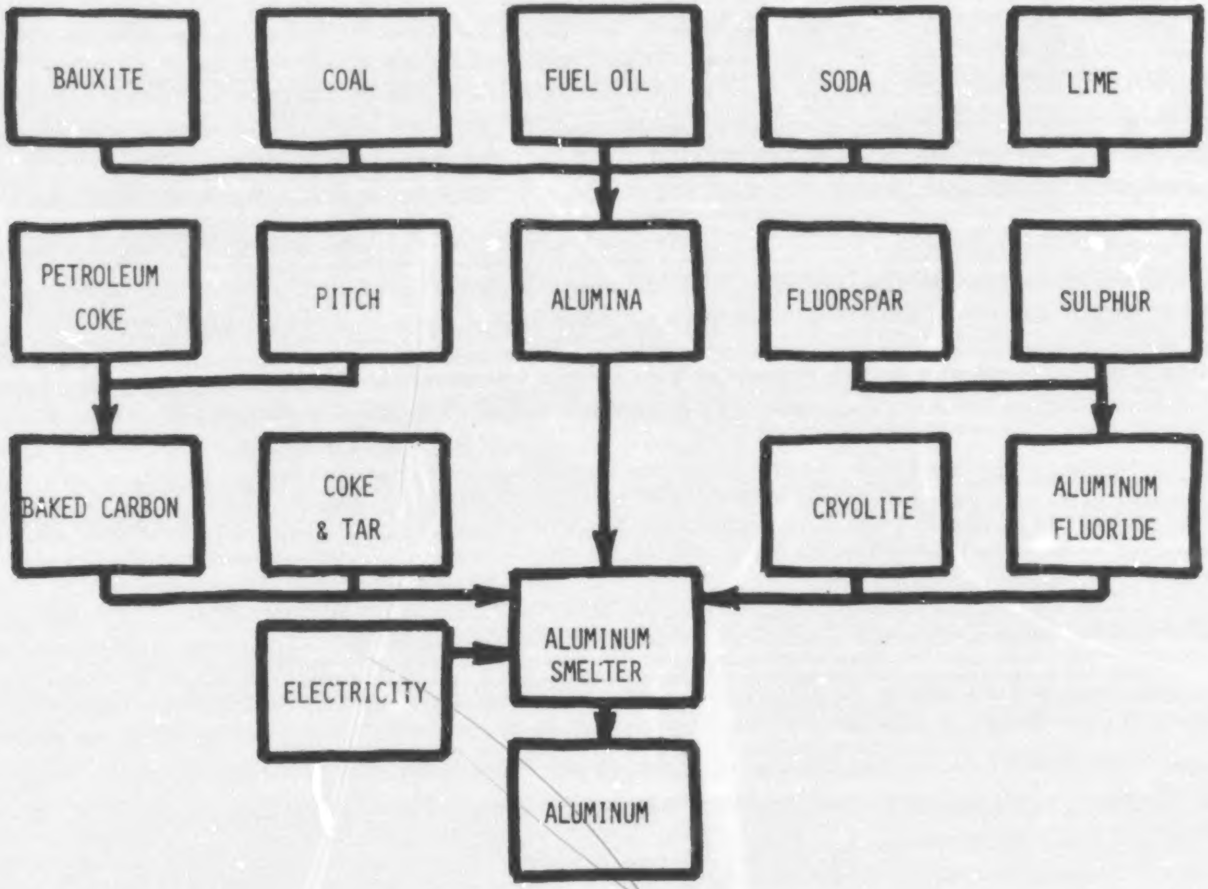
83

MW2-6

ELECTRIC FURNACE


ELECTRODES
REFRACTORY BRICK
CHARGING DOOR
SPOUT
MOLTEN METAL
SLAG
ELECTRIC ARC PATH

ALUMINUM REFINING


BAUXITE
COAL
FUEL OIL
SODA
LIME
PETROLEUM COKE
PITCH
ALUMINA
FLUORSPAR
SULPHUR
BAKED CARBON
COKE & TAR
CRYOLITE
ALUMINUM FLUORIDE
ALUMINUM SMELTER
ELECTRICITY
ALUMINUM

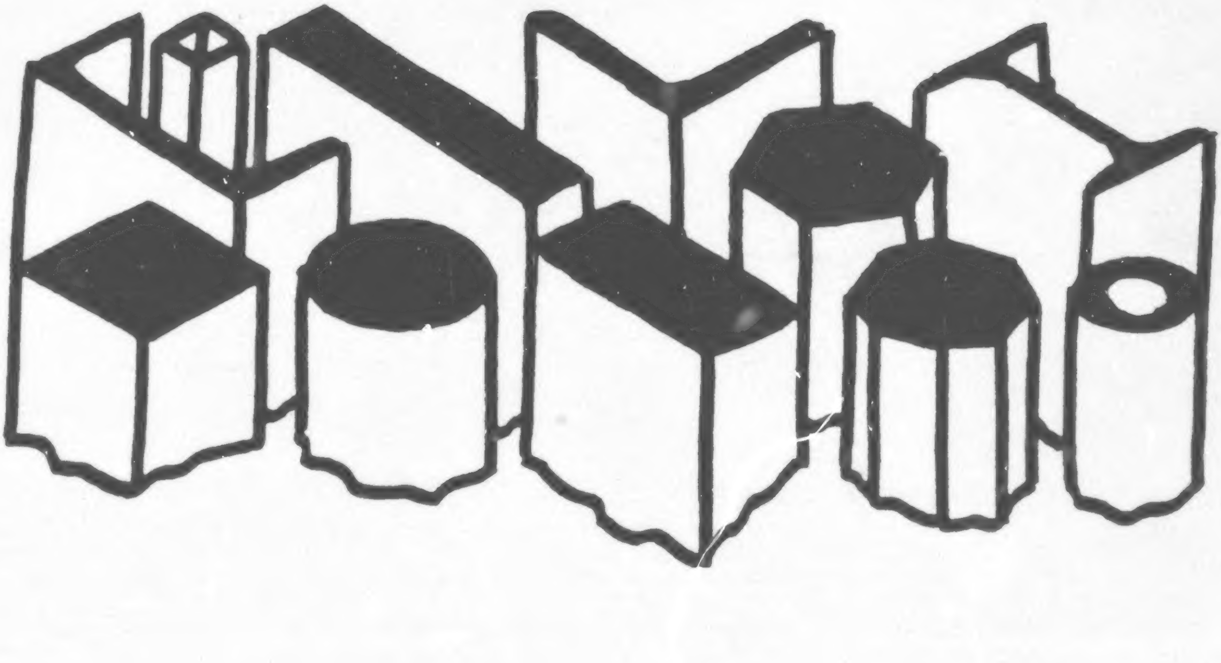
MW2-7

MW2-8

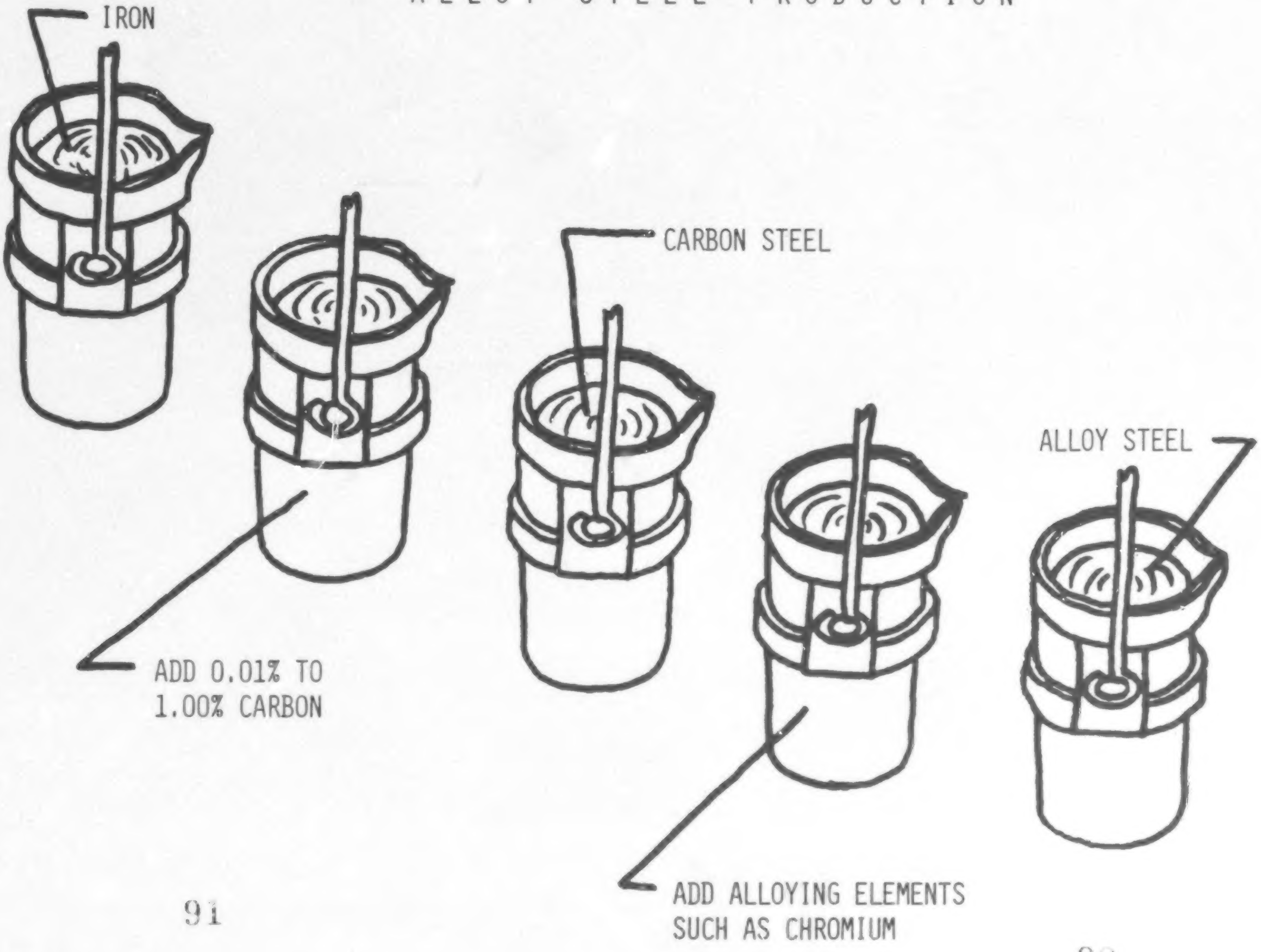
FERROUS METALS

CAST IRON	3.0 TO 4.0% CARBON
STEEL	
HIGH CARBON STEEL	0.55% + CARBON
MEDIUM CARBON STEEL	0.35 TO 0.50% CARBON
LOW CARBON STEEL	0.08 TO 0.35% CARBON
WROUGHT IRON	LESS THAN 0.08% CARBON

EXAMPLES OF METAL SHAPES

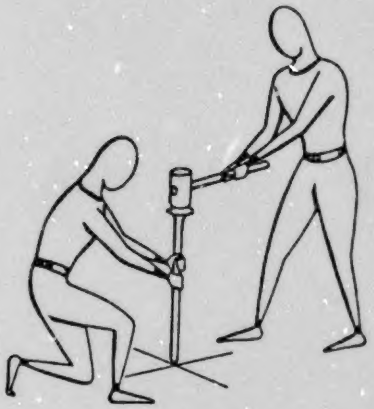


ALLOY STEEL PRODUCTION

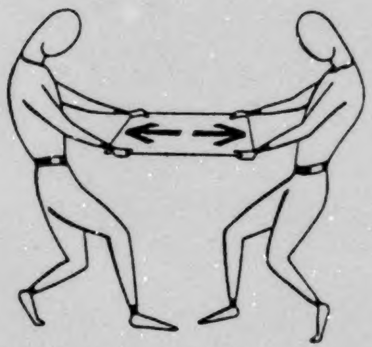

IRON
CARBON STEEL
ALLOY STEEL
ADD 0.01% TO 1.00% CARBON
ADD ALLOYING ELEMENTS SUCH AS CHROMIUM

MW2-10

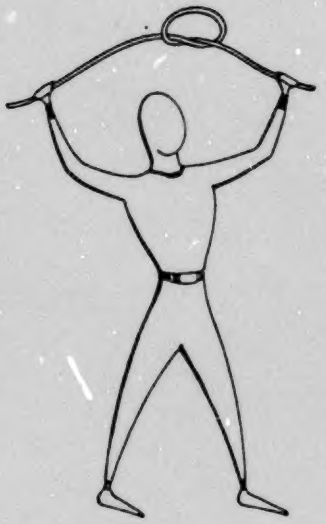
TESTING TERMINOLOGY



HARDNESS



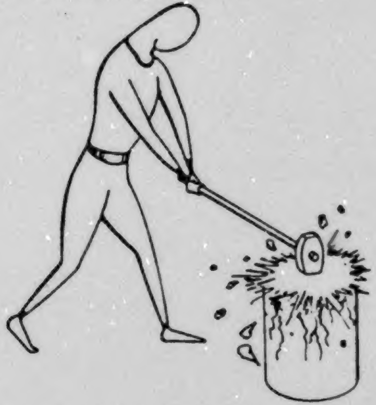
TENSILE STRENGTH



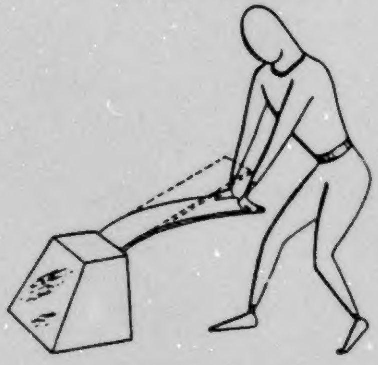
DUCTILITY

MW2-11

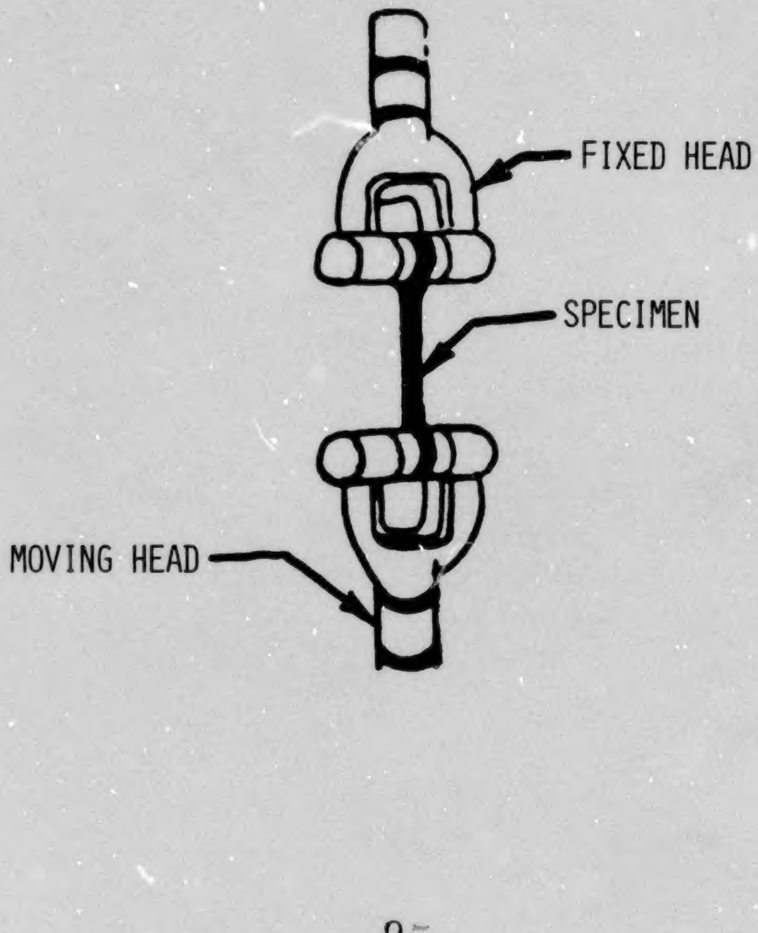
BRITTLENESS



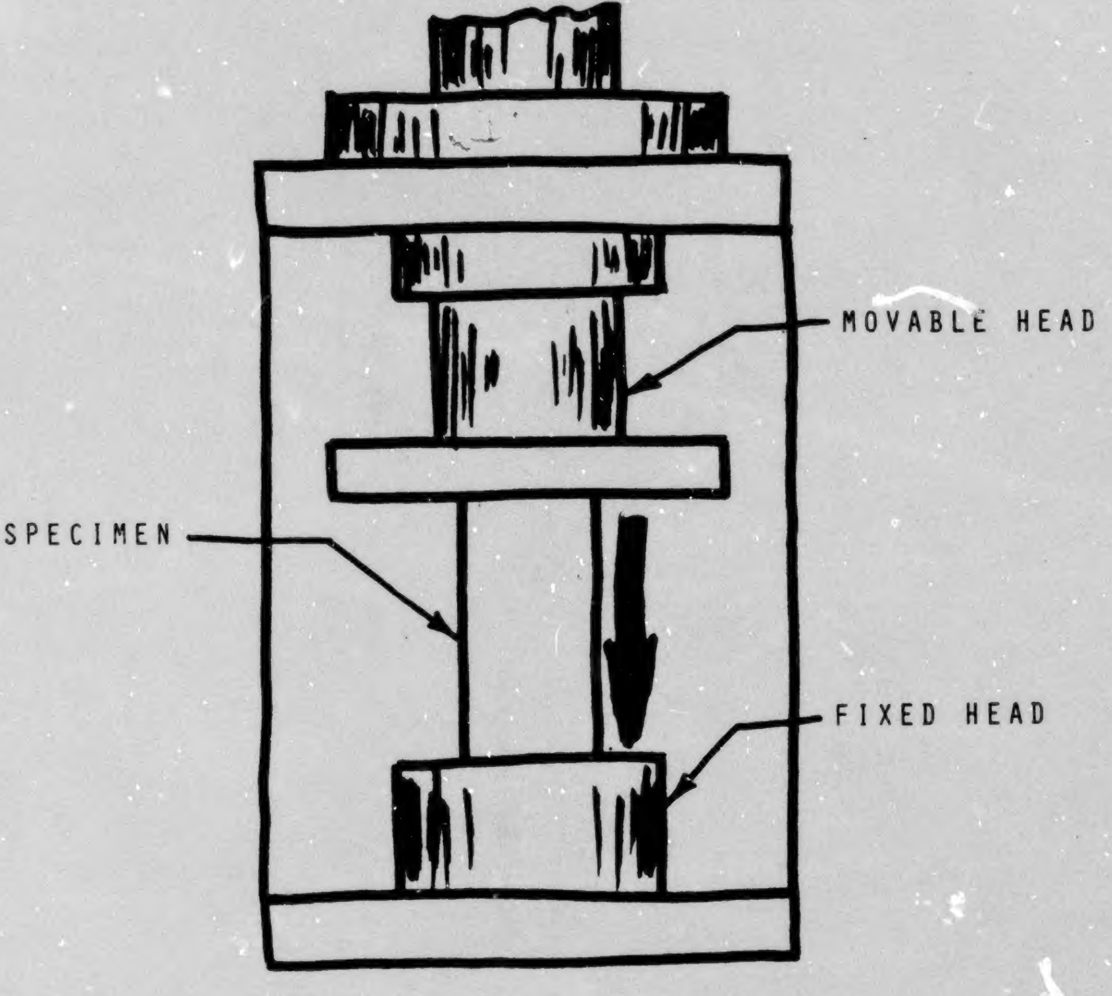
ELASTICITY



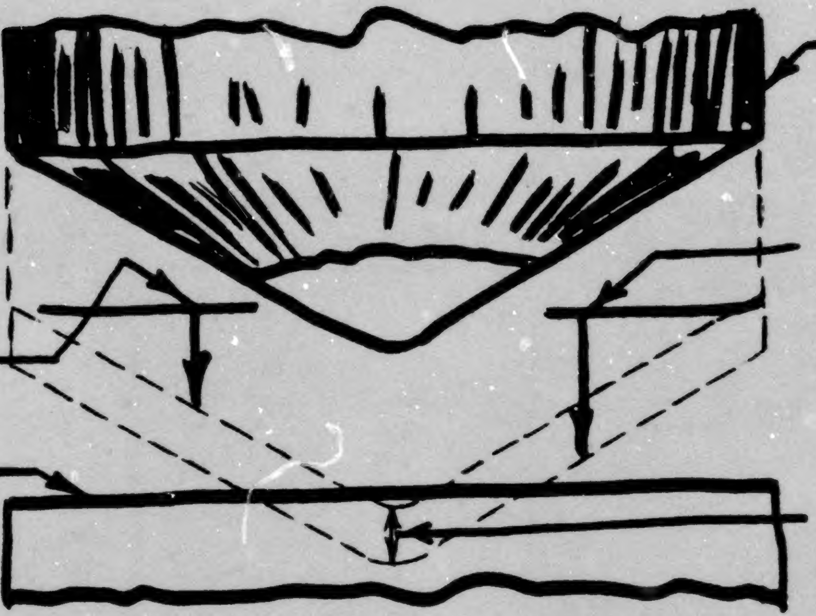
TESTING FOR TENSILE STRENGTH


FIXED HEAD
SPECIMEN
MOVING HEAD

TEST FOR COMPRESSION STRENGTH


MOVABLE HEAD
SPECIMEN
FIXED HEAD

TESTING FOR HARDNESS



DIAMOND PENETRATOR

DEPTH TO WHICH PENETRATOR IS FORCED BY 10 KG. MINOR LOAD

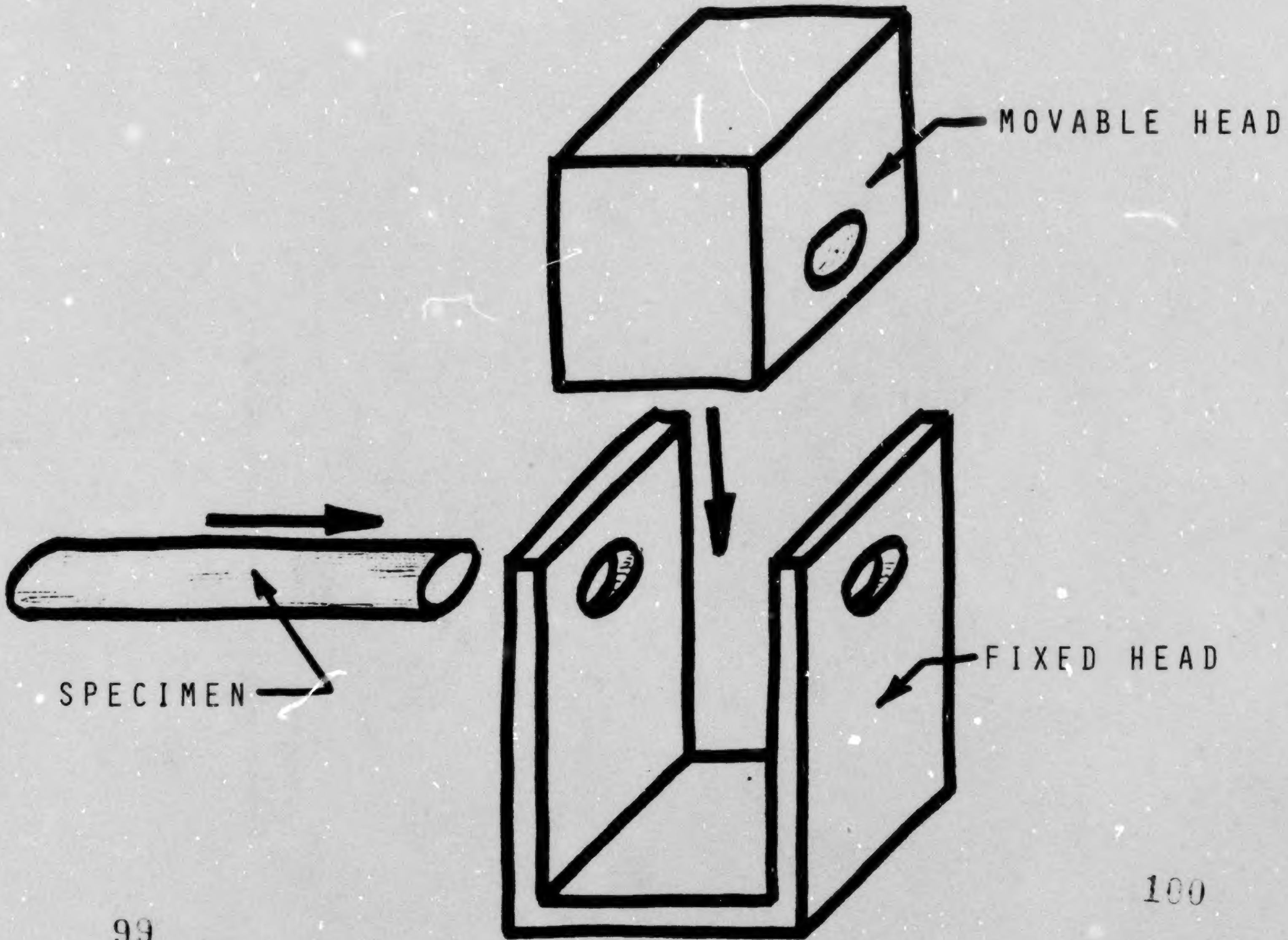
DEPTH TO WHICH PENETRATOR IS FORCED BY 150 KG. MAJOR LOAD

SURFACE OF SPECIMEN

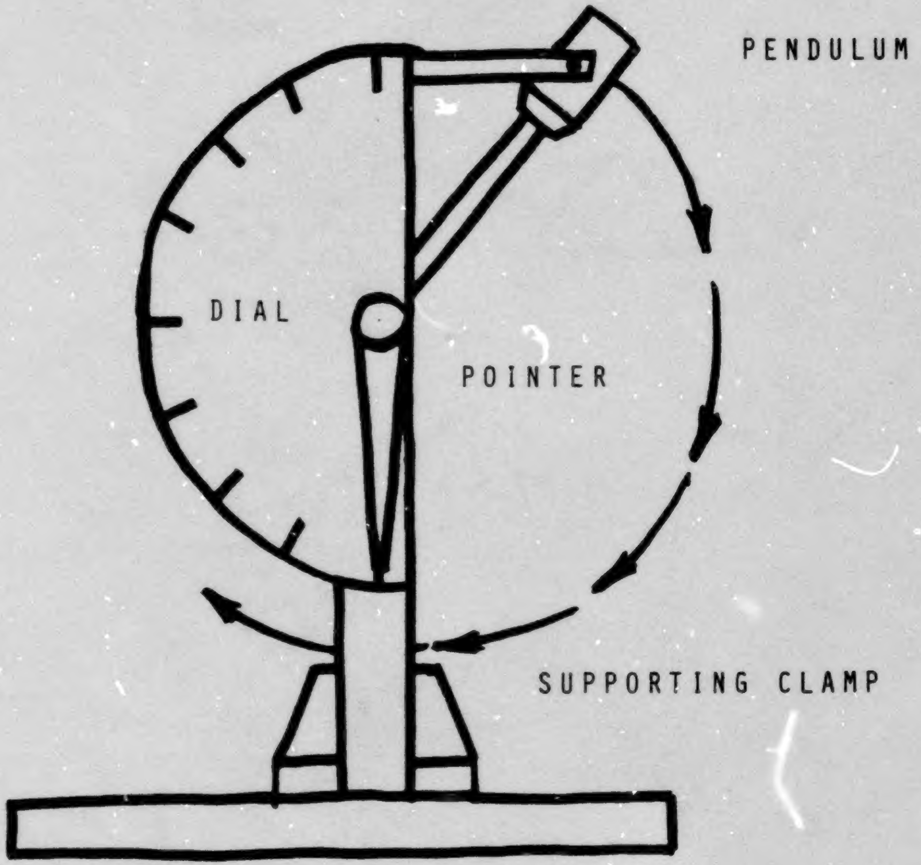
INCREMENT IN DEPTH DUE TO INCREMENT IN LOAD IS THE LINEAR MEASUREMENT THAT FORMS THE BASIS OF ROCKWELL HARDNESS TESTER READINGS

MW2-14

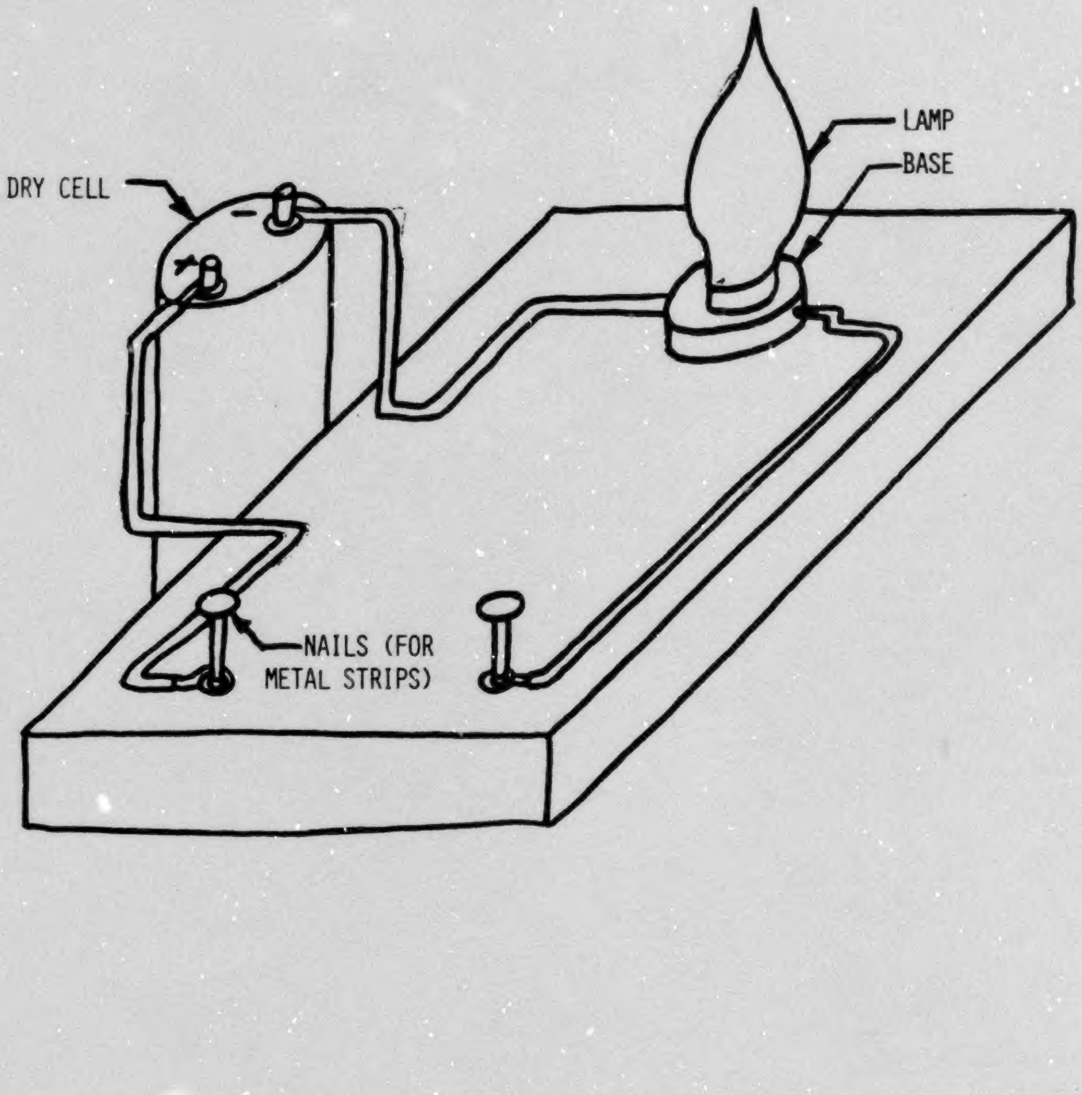
TESTING FOR SHEAR STRENGTH


MOVABLE HEAD
SPECIMEN
FIXED HEAD

TESTING FOR IMPACT STRENGTH


PENDULUM
DIAL
POINTER
SUPPORTING CLAMP

AN ELECTRICAL CIRCUIT TO DETERMINE ELECTRICAL PROPERTIES


LAMP
BASE
DRY CELL
−
+
NAILS (FOR METAL STRIPS)

3

Safety

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. dress properly to work in the industrial technology laboratory;
2. select the proper safety protection equipment;
3. perform laboratory maintenance and care;
4. safely perform general laboratory activities;
5. safely use metalworking hand tools;
6. safely handle various forms of metal stock;
7. safely use the metalworking grinder;
8. safely use the drill press;
9. work safely in the foundry;
10. safely use sheet metal cutting machines; and
11. safely use sheet metal forming machines.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

safety glasses
goggles
hearing protectors
compressed air
chips
chip screen
guards
face shield
chatter/vibrations
leather/asbestos
ventilation

TEACHING AIDS

- Overhead projector
- Test Key: General: 1-D, 2-B, 3-C, 4-B, 5-A, 6-A, 7-B, 8-D; Hand Tools: 1-B, 2-D, 3-C, 4-A, 5-D, 6-D, 7-A; Grinder: 1-C, 2-D, 3-B, 4-B, 5-C, 6-B, 7-A; Drill Press: 1-B, 2-C, 3-A, 4-A; Foundry: 1-D, 2-B, 3-C, 4-B, 5-A, 6-A; Sheet Metal: 1-C, 2-B, 3-D, 4-A, 5-C, 6-B.

- Transparencies: You will find transparency MW3-1 and Handouts No. 1 through 3 at the end of this unit. If you wish, these may be duplicated in quantity and given as handouts to students while they are studying the different aspects of this unit.

  MW3-1: The Prepared Student

  Handout No. 1: Safety Guide for Color Coding
  Handout No. 2: Safety Signs
  Handout No. 3: Labeling of Exposed Pipes

SUGGESTED REFERENCES

Budzik, R. S. Sheet Metal Technology. Indianapolis, Ind.: Bobbs-Merrill, 1981.

Feirer, J. L., and Lindbeck, J. R. Basic Metalwork. Peoria, Ill.: Charles A. Bennett, 1978.

Graham, G. S. Metalworking: An Introduction. Belmont, Calif.: Breton Publishers, 1981.

Groneman, C. H., and Feirer, J. L. Getting Started in Metalworking. New York: McGraw-Hill, 1979.
Miller, W. R., et al. Metalworking. Bloomington, Ill.: McKnight, 1978.
Walker, J. R. Modern Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.

SENTENCE OUTLINE

I. General safety rules (Transparency MW3-1)
  A. Proper dress
    1. Do not wear any loose clothing.
    2. Do not wear long-sleeve shirts—or roll above the elbow if you do.
    3. Do not wear canvas shoes. They give no resistance to hard objects dropped on the feet.
    4. Remove all rings, watches, bracelets, or "hanging" jewelry.
    5. Restrain all long hair.
    6. If you wear a tie, remove it.
  B. Safety protection
    1. Always wear safety glasses (goggles) in the lab.
    2. If your work is noisy, wear hearing protectors.
    3. Protect against inhaling noxious fumes.
  C. Laboratory maintenance and care
    1. Place all metal scrap in a scrap box.
    2. Wipe up any fluid that has spilled.
    3. Place all oily rags in a closed, metal container.
    4. Keep aisles clear at all times.
  D. Laboratory activities
    1. The lab is not a place for horseplay.
    2. Most accidents are caused because simple rules were not observed.
    3. Do not "daydream" while working.
    4. Assume all metal to be sharp and/or hot, especially any metal scraps.
    5. Be sure you have sufficient light to see clearly.
    6. Never use compressed air to clean a work area; flying chips are dangerous.
    7. Immediately inform the instructor of any cut, bruise, scratch, or burn—no matter how minor it may be.

II. Hand tool safety
  A. General safety rules
    1. Use the correct tool for the job.
    2. All pointed tools should be placed on the bench with the points away from you.
    3. Do not carry tools in pockets.
    4. Put tools away when you are not using them.
    5. Always use a brush to remove chips from a bench or from a machine.
  B. Saws
    1. Never use a hacksaw that has a loose blade.
    2. When sawing, make sure the work is held securely in the vise.
    3. When sawing, ease up on the pressure when approaching the end of the cut.
  C. Hammers
    1. Never use a hammer with a loose, split, or broken handle.
    2. Do not use hammers with chipped heads.
  D. Wrenches
    1. Be sure the wrench fits the nut snugly—the wrong size wrench can slip and injure the hand.
    2. Pull a wrench toward you—do not push it away from you.

E. Screwdrivers
  1. Use the correct size blade of a screwdriver for the slot of the screw.
  2. Never hold the work in your hand when using a screwdriver.
  3. Never use a hammer on a screwdriver handle.
F. Chisels
  1. Never use a chisel that has a burred head.
  2. Use a chip screen when using a chisel.
G. Files: Always use a file with a handle.

III. Material handling
A. Wear gloves when handling sheet metal or large pieces of stock.
B. Lift with your leg muscles—not your back.
C. Get help when moving anything heavy.
D. Get help when handling long stock.

IV. Machine tool safety (Handout No. 1 and Handout No. 2)
A. General safety rules
  1. Do not operate any machine without prior approval of the instructor.
  2. Operate machines only with **all** guards in place.
  3. Keep the floor around all machines clear of chips and/or scrap.
  4. Keep away from moving belts.
  5. Stop any machine before making any measurements or adjustments.
  6. Never attempt to remove any chips or cuttings while the machine is running.
  7. Do not talk to any classmates while operating any machine.
  8. Do not walk away from any machine until it has stopped running.
B. Grinding machine
  1. Wear a face shield over your safety glasses (goggles).
  2. Protect against inhaling dust of any kind, especially from grinding wheels.
  3. Stand to one side of the machine when first starting.
  4. If the wheel chatters or vibrates, turn off the machine immediately.
  5. Use the face of the wheel only—never the sides.
  6. Keep the work rests as close to the wheel as possible.
  7. Do not adjust the tool rest while the wheel is moving.
  8. Feed the work slowly, gradually, and without much pressure.
C. Drill press
  1. Never wear gloves when operating the drill press.
  2. The workpiece should be held securely in a vise, jog, or fixture, or bolted to the table.
  3. Remove chuck wrenches from the drill chuck immediately after using.
  4. Keep your head back and well away from the moving parts.
  5. Run drill only at the correct speed and feed.
  6. Do not reach around or behind a revolving drill.
  7. File or scrape all burrs from drilled holes.
D. Casting/Foundry
  1. Molds
    a. Never lift a filled mold by yourself—get the help of another person.
    b. Never attempt to break open a hot mold.
  2. Correct clothing for pouring
    a. Wear a full face shield over your goggles.
    b. Wear long leather/asbestos gloves.
    c. Wear a full leather/asbestos apron.
    d. Wear leather/asbestos arm guards.
    e. Wear leather/asbestos knee leggings that extend over the shoe tops.
    f. Wear heavy leather shoes.
  3. Preparation for pouring
    a. The floor around the furnace and pouring area should be clear at all times.
    b. Be sure that the crucible is in good condition.
    c. Check the crucible tongs and shank for proper condition and adjustment.
    d. Study the furnace start-up and shut-down procedures.
    e. Proper ventilation is a necessity.

        4. Heating/Pouring
            a. Preheat all metal to remove any possible moisture—never add a cold piece of metal directly into a heating crucible.
            b. Only the pourers and one assistant should be in the pouring area.
            c. Pour smoothly—no "jerky" motions—without interruption.
            d. If there is any metal left, pour it into ingot molds. Do not leave any metal in the crucible.
            e. Assume all castings to be hot.

V. Sheet metal safety
    A. Machine tools
        1. Cutting machines
            a. Keep your hands clear of the blade of the shears.
            b. Keep your feet away from the foot pedal of the shears.
            c. Do not reach behind shear blades to hold or catch small pieces of metal.
        2. Forming machines
            a. Keep your hands and fingers clear of the rotating parts on forming machines.
            b. When operating a brake, do not permit anyone else to close the brake while you are holding the metal.
            c. Never place your hands between the dies of a press brake.
    B. Miscellaneous (Handout No. 3)
        1. Do not use steel hammers to form sheet metal over hardened steel surfaces such as anvils or stakes.
        2. Do not attempt to catch or stop falling sheet metal.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pencils, pens, etc.
- Notebook (preferably a 3-ring binder)
- Safety glasses/goggles
- Apron

SUGGESTED STUDENT ACTIVITIES

1. Produce, and use, a synchronized slide/tape program on safety in **your** lab. Ask several questions (on the tape) during the presentation that will require the students to respond on paper.
2. Ask students to design and produce safety posters for the lab.
3. Ask students to develop a bulletin board display on eye safety.
4. Invite an industrial safety expert to evaluate your lab; ask for recommendations to improve it.
5. Discuss safe methods of handling sheet metal, hot metal, and metal with sharp edges.
6. What do the initials OSHA mean? Have the students research the OSHA program and how some of the rules and regulations apply to the lab (for example, color coding).
7. As each hand tool and machine tool is introduced, demonstrate and discuss the correct and safe use, care, inspection, and maintenance of that item.
8. Administer safety exams on general safety rules, on safety rules for using hand tools, and on each machine that the students will use.

Vocabulary Worksheet

1. safety glasses
2. goggles
3. hearing protectors
4. compressed air
5. chips
6. chip screen
7. guards
8. face shield
9. chatter/vibrations
10. leather/asbestos
11. ventilation

TEST

UNIT 3: SAFETY (GENERAL)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Proper dress for the industrial technology laboratory is--
A. canvas shoes
B. watch
C. tie
D. short sleeve shirt

___ 2. Always wear--
A. hearing protectors
B. safety glasses
C. loose clothing
D. gloves

___ 3. Place all metal scrap in--
A. a waste basket
B. the metal storage rack
C. a scrap box
D. oily rag container

___ 4. Place all oily rags in--
A. a scrap box
B. a closed metal container
C. a waste basket
D. the appropriate drawer

___ 5. Assume all metal to be--
A. sharp
B. heavy
C. yours
D. in the wrong place

___ 6. The lab is not a place for--
A. horseplay
B. study
C. work
D. safety

___ 7. When cleaning a work area, never--
- A. wear goggles
- B. use compressed air
- C. use a brush
- D. ask for help

___ 8. All pointed tools should be--
- A. placed on a bench with the points toward you
- B. carried in your pockets
- C. left on the bench when you are finished with them
- D. placed on the bench with the points away from you

Optional Test Assignment. At the conclusion of this test, you are to correctly dress for work in the industrial technology laboratory. When you are ready, ask the instructor to inspect you. If you pass inspection, the instructor will sign here:

____

TEST

UNIT 3: SAFETY (HAND TOOLS)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

__ 1. Never use a hacksaw--
A. with two hands
B. that has a loose blade
C. that has a tight blade
D. that has sharp teeth

__ 2. When sawing--
A. make sure you hold the work tightly in your hand
B. do not ease up on the pressure when approaching the end of the cut
C. ask for assistance in holding the stock
D. make sure the work is held securely in the vise

__ 3. Never use a hammer--
A. with a chipped head
B. with a loose, split, or broken handle
C. all of the above
D. none of the above

__ 4. When using a wrench--
A. pull it toward you
B. be sure you have a loose fit that will "give" slightly
C. all of the above
D. push it away from you

__ 5. When using a screwdriver--
A. hold the work in your hand
B. use a hammer on the handle if the screw is stuck
C. all of the above
D. none of the above

__ 6. When using chisels, never--
A. use a hammer
B. use a chip screen
C. use one without a handle
D. use a chisel that has a burred head

___ 7. When filing--
A. use a handle
B. use a chip screen
C. use gloves
D. hold the work in your hand

TEST

UNIT 3: SAFETY (GRINDER)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. When using the grinder, always wear--
A. gloves
B. tie
C. face shield over your safety glasses
D. loose clothing

___ 2. When first starting the machine--
A. walk away from it
B. stand in front of it
C. immediately begin using it
D. stand to one side of it

___ 3. If the wheel chatters or vibrates--
A. adjust the work rest
B. immediately turn off the machine
C. feed the work slowly
D. feed the work faster

___ 4. When using the grinder--
A. use the sides of the wheel
B. use the face of the wheel
C. use the face or the sides of the wheel
D. use both the face and the sides of the wheel

___ 5. The correct position for the work rest is--
A. 1/8" away from the wheel
B. 1/4" away from the wheel
C. as close to the wheel as possible
D. it really doesn't matter

___ 6. Adjust the work rest--
A. with the wheel moving
B. with the wheel stopped
C. it does not matter
D. the work rest cannot be adjusted

___ 7. When grinding--

A. feed the work slowly and without much pressure
B. feed the work quickly but without much pressure
C. feed the work slowly and with a lot of pressure
D. feed the work quickly and with a lot of pressure

TEST

UNIT 3: SAFETY (DRILL PRESS)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. When using the drill press--
A. wear gloves
B. wear safety glasses
C. wear tie
D. wear loose clothing

___ 2. The work should not be held--
A. in a vise
B. in a jig
C. in your hand
D. in a fixture

___ 3. Remove chuck wrenches--
A. immediately after using
B. before turning on the machine
C. before leaving the machine
D. after you are finished with a drilling operation

___ 4. When using the drill press--
A. stand with your head back and well away from any moving parts
B. stand to one side with your head close to the work so you can see what you are doing
C. stand behind the press
D. it does not matter where you stand as long as you can see what you are doing

TEST

UNIT 3: SAFETY (FOUNDRY)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. When pouring molten metal--
A. wear full face shield over your goggles, and heavy leather shoes
B. wear long leather/asbestos gloves and a full leather/asbestos apron
C. wear leather/asbestos arm guards and knee leggings
D. all of the above

___ 2. After pouring--
A. break open the hot mold
B. ask another person to help you lift the filled mold
C. wear leather/asbestos arm guards and knee leggings
D. all of the above

___ 3. When heating the metal--
A. add cold metal directly into the crucible
B. do not add any metal to that already in the crucible
C. preheat cold metal to remove any moisture
D. none of the above

___ 4. When pouring--
A. pour rather quickly to fill the mold before the metal cools
B. pour smoothly without interruption
C. pour in several short bursts to allow the metal to completely fill the mold
D. pour very slowly to be sure the mold is completely filled

___ 5. If there is any metal left--
A. pour it into ingot molds
B. pour it back into the crucible
C. leave it in the shank
D. return it to the tongs

___ 6. Assume that all castings are--
A. hot
B. sharp
C. cold
D. yours

TEST

UNIT 3: SAFETY (SHEET METAL)

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Keep your hands away from the __________ of the shears.
A. gauge
B. foot pedal
C. blade
D. guard

___ 2. Keep your feet away from the __________ of the shears.
A. gauge
B. foot pedal
C. blade
D. guard

___ 3. When using the shears--
A. do not reach behind the blade
B. do not hold small pieces of metal
C. do not catch small falling pieces of metal
D. all of the above

___ 4. Keep your fingers away from the rotating parts of the--
A. forming machines
B. shears
C. press brake
D. all of the above

___ 5. Never place your hands between the dies of the--
A. forming machines
B. shears
C. press brake
D. all of the above

___ 6. To form sheet metal over stakes, use--
A. ball peen hammer
B. mallet
C. forming hammer
D. forging hammer

HANDOUT NO. 1

SAFETY GUIDE FOR COLOR CODING

COLOR	ITEMS	COLOR	ITEMS
RED	emergency stop switches fire alarm boxes fire extinguishers fire blanket containers fire hose cabinets fire exit signs fire sand pails cans/cabinets that contain flammable material (contents labeled in white)	ORANGE	exposed edges pulleys gears rollers power operated jaws parts of a machine that crush that cut that shock guards that cover blades inside of fuse/circuit breaker boxes machine switch box covers inside of all switch boxes
YELLOW	parts of a machine that move adjustable levers/handles wheels knobs parts of equipment that move handrails/guardrails vertical edges of platforms/steps	YELLOW/BLACK (diagonals)	low overhead beams or other obstacles parts of machines that stick out edges of various machine tables rear of shaper ram
BLUE	outside of large switch boxes	IVORY/BUFF	vertical edges of all tables and benches background where instruments are used
GREEN	first aid kits (with white cross) bulletin boards for safety information safety showers eye wash station stretcher location	NONGLOSS PALE BLUE/ GREEN/GRAY	all equipment body of all machines

HANDOUT NO. 2

Safety Signs

I. Danger Signs
  A. Basic Design
    1. Red oval background
    2. White letters
  B. Optional Lower Section
    1. White background
    2. Black letters which state the exact danger

II. Caution Signs
  A. Basic Design
    1. Black background
    2. Yellow letters
  B. Optional Lower Section
    1. Yellow background
    2. Black letters which state the reason for the caution

III. Safety Instructions Signs (Fire Drill Instructions, etc.)
  A. Upper Title Section
    1. Green background
    2. White letters ("Safety Instructions: ____________")
  B. Lower Section
    1. White background
    2. Black letters

IV. Basic Information Signs ("Out of Order," "Do Not Operate," "Do Not Move," etc.)
  A. Blue background
  B. White letters

HANDOUT NO. 3

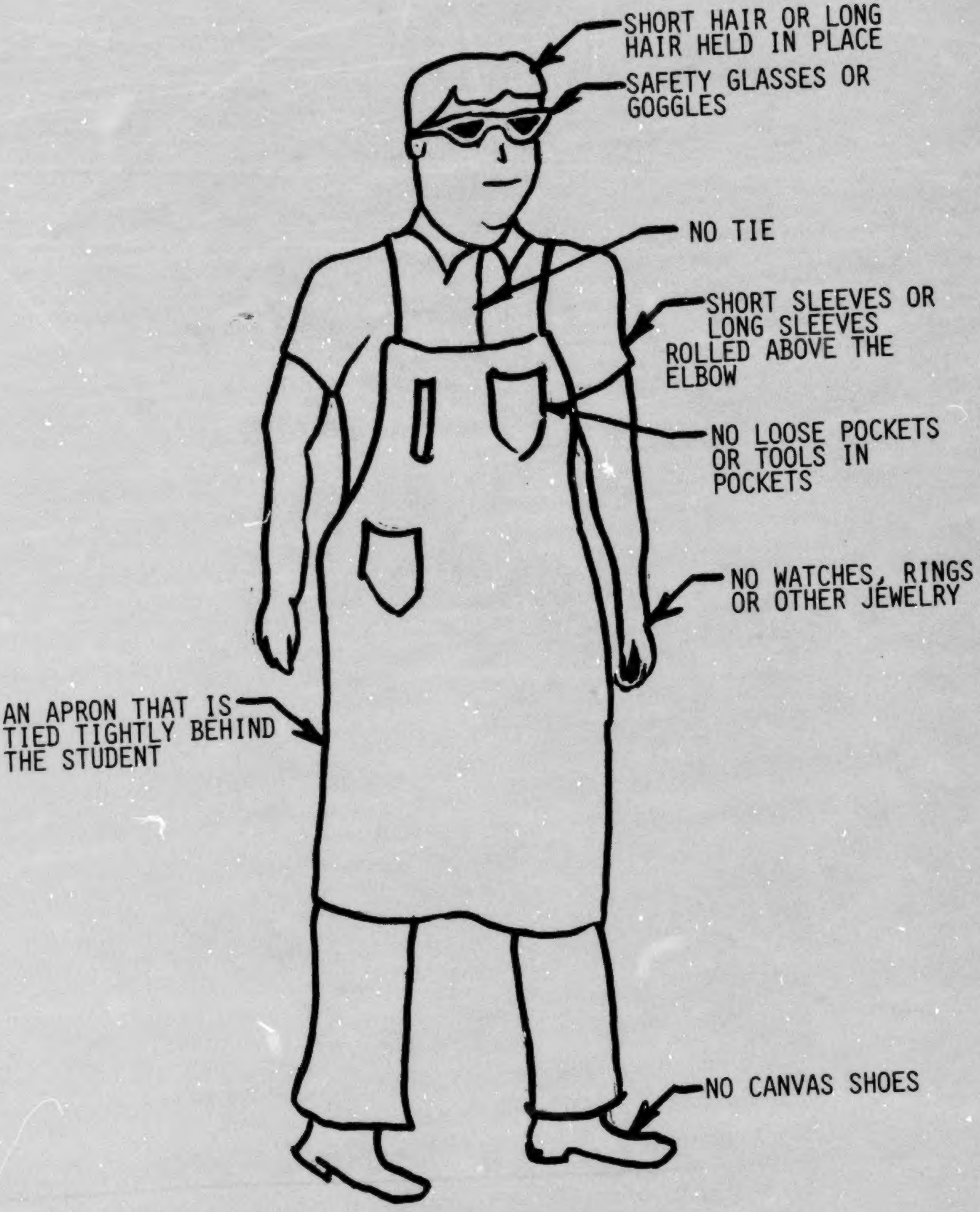
Labeling of Exposed Pipes

I. Water for the Building Fire Sprinkler System
   A. Red background
   B. White letters

II. Possibly Dangerous Substances (Steam, Gases, Acids, etc.)
   A. Yellow background
   B. Black letters

III. Drinking Water/Compressed Air
   A. Green background
   B. Black letters

THE PREPARED STUDENT


SHORT HAIR OR LONG HAIR HELD IN PLACE
SAFETY GLASSES OR GOGGLES
NO TIE
SHORT SLEEVES OR LONG SLEEVES ROLLED ABOVE THE ELBOW
NO LOOSE POCKETS OR TOOLS IN POCKETS
NO WATCHES, RINGS OR OTHER JEWELRY
AN APRON THAT IS TIED TIGHTLY BEHIND THE STUDENT
NO CANVAS SHOES

4

Laboratory Management

ORGANIZATION

This unit is divided into three separate sections, each dealing with a different aspect of laboratory management and the teaching of leadership skills. Section A deals with "Youth Leadership" and how these skills can be developed. Section B, "Entrepreneurship," covers material on the free enterprise system and how entrepreneurs (or risk-takers) provide leadership in a capitalistic system. Section C, on "Laboratory Organization," provides means of teaching leadership through the study of management. This section also explores the leadership qualities an employer looks for in an employee.

Section A: Youth Leadership

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. participate in organizing a personnel system, conducting a meeting and using democratic decision-making procedures;
2. list industrial and community resources, select at least three appropriate to the unit of study, and arrange for a speaker or tour;
3. conduct a survey of industries or use a questionnaire during interview with industrial career persons;
4. plan, organize, and carry out activities or projects that contribute to an improvement in, or service to, the school and/or community;
5. communicate with others to determine the need for product or service;
6. organize and manage their own business to produce or render a service of economic value that will have sales appeal to students or adults; and
7. organize, manage, and participate in contests, exhibits, or demonstrations which motivate students to learn and provide recognition for their achievements.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

personnel system
decision making
vendor
enterprise

organize
manage
technical
industrial and commercial resources

TEACHING AIDS

- Overhead projector
- Transparencies: You will find transparencies MW4-1 and MW4-2 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW4-1: Calendar of Activities
MW4-2: Organizational Structure

- Handouts: You will find Handouts No. 1 through No. 10 at the end of this unit. If you wish, these may be duplicated in quantity and given to students while they are studying different aspects of this unit.

  Handout No. 1: The Student Association as Personnel System with Uniform Titles
  Handout No. 2: AIASA Personnel In-Class Duties
  Handout No. 3: Committee Duties
  Handout No. 4: In-Class Meeting Procedures
  Handout No. 5: How Motions Are Made
  Handout No. 6: Duties for In-Class Use of Community Resources
  Handout No. 7: Duties for In-Class Service Projects
  Handout No. 8: Duties for In-Class Enterprising Products
  Handout No. 9: Duties for In-Class Contests or Recognition
  Handout No. 10: Regional, State, and National Recognition Events for Industrial Arts Students

SUGGESTED REFERENCES

Achievement Program. Reston, Va.: American Industrial Arts Association, 1983.

AIASA Guide for Industrial Arts Program Standards for Industrial Arts Program. Blacksburg: Virginia Polytechnic Institute and State University, November 1981.

Barnes, J. L. "American Industrial Arts Student Association Student Record Book." Unpublished research, Virginia Polytechnic Institute and State University, Blacksburg, 1983.

Guide II: Student Association Activities in Industrial Arts Instruction. Richmond, Va.: Department of Education, 1979.

Texas Industrial Arts Student Association. Austin: Texas Education Society, 1975.

Texas Industrial Arts Student Association 1983 Handbook Regional and State Competition. Austin: Texas Education Agency, 1983.

Willcox, G. R. "AIASA: As a Teaching Tool," Paper presented at the meeting of the American Industrial Arts Association, Pittsburgh, Pennsylvania, March 23, 1981.

SENTENCE OUTLINE

I. Using personnel/leadership development systems (Handout No. 1)
   A. All organizations use systems to manage group activities. (Transparency MW4-1)
   B. The duties of personnel who hold various positions in the system rely on the total group working together for the benefit of all in the organization. (Transparency MW4-2, Handout No. 2)
   C. The personnel system is made up of officers and committees who are responsible for carrying out the duties and responsibilities of the organization. (Handout No. 3)
   D. It is important for students to work together and to develop leadership skills.
   E. Democratic decision making is developed through the process of conducting meetings and learning how to make motions in those meetings. (Handouts No. 4 and No. 5)

II. Using industrial community resources (Handout No. 6)
   A. Making contacts with community and industrial leaders will help develop leadership skills.
   B. Part of leadership development is learning how to survey industry and to use a questionnaire during an interview.
   C. Community resources are an extension of the industrial arts classroom, which allows students a more in-depth exposure to personnel/leadership development.

III. Providing a school or community service (Handout No. 7)
   A. Service or community projects provide benefits to others and to those who provide them.
   B. Service projects enable students to use their technical know-how to help others in the same way that inventions help solve problems.

IV. Enterprising a product or service (Handout No. 8)
   A. In the United States, the industrial system is called free enterprise—meaning that we are free to establish any kind of business we wish and to make almost any product we wish.
   B. Through free enterprise, companies are encouraged to produce new products which are protected by patents.
   C. Products are sold for their economic value, and services are provided for their economic value.

V. Recognizing student achievements (Handouts No. 9 and No. 10)
   A. AIASA contests and booth exhibits provide opportunities for students to develop leadership skills through competing and interacting with other students on the regional, state, and national levels.
   B. Through the various contests and exhibits, students will be recognized for outstanding individual and chapter work.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)

SUGGESTED STUDENT ACTIVITIES

1. Students will participate in discussion of the various positions in the personnel/leadership system. After election to an office or committee position, they will practice the duties. Their duties will help them conduct class meetings and manage laboratory activities. During class meetings, the student will use parliamentary procedures to make democratic decisions. These experiencies help all students learn how meetings are conducted by AIASA and other groups.
2. All students will study the handout describing the personnel system used in the class.
3. A nominating committee will be formed to work with the teacher and to prepare a ballot.
4. Students elected to office or committee positions will study duties and learn how to conduct a meeting.
5. Parliamentary procedures will be learned in order that motions are used by all students.
6. Class officers will conduct a meeting to decide which industrial and community resources will be used to learn a certain unit of Industrial Arts. A community resources committee meets to list and select appropriate speakers or industrial tours. The class will vote on the best resource. With help from the teacher and the principal, the speaker is called, or a letter is written. If all students are not permitted to visit the industry, the committee may visit and videotape the industry, and then report to the class. Afterwards, a thank-you letter should be written to the persons who assisted the class or committee.
7. Class officers could conduct a class meeting whereby the teacher will give a lesson on using community resources. The historian serves on the committee. After the committee selects appropriate resources, the officers will conduct a meeting to select one. The officers will announce when the next class meeting will be held to allow time for this activity.

8. Committee members should use the library, Chamber of Commerce directories, or Yellow Pages to find industry or business related to the unit of study. After the class votes on the best resource, the committee should write a letter to invite a speaker or to arrange a tour. The parliamentarian could obtain permission forms from the principal's office, if required. A follow-up is made in order to check on arrangements. If the class is not permitted to visit the industry, the committee may visit and videotape the tour for the class. A thank-you letter is written to the speaker or to the industry. Records are kept in a file for use by other class or school chapters.
9. Class officers could conduct a class meeting to decide which service project will be provided by the class to help the school or community. A service committee will organize the project and involve class members in laboratory work to complete the project for delivery or pickup.
10. Class officers could conduct a meeting to decide which product or service would be of value to the class or AIASA. The class should work as a group to form the enterprise. An enterprise committee should organize the technical and financial details for the class members. The entire class should work to make a profit for the class or to pay for AIASA dues or other activities.
11. Class officers could conduct a meeting to decide which contests will provide recognition to students who achieve. A recognition committee could organize contests, exhibits, or demonstrations for the class. Class members should compete with each other, or work together on a recognition event such as an open house.

Vocabulary Worksheet

(Youth Leadership)

1. personnel system
2. decision making
3. vendor
4. enterprise
5. organize
6. manage
7. technical
8. industrial and commercial resources

Section B: Entrepreneurship

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. describe the fundamental differences between the three major economic systems of communism, socialism, and capitalism;
2. list several ways that individuals and companies can invest capital to make more money;
3. describe the free enterprise system as it relates to the industrial system in the United States;
4. describe an entrepreneur;
5. describe the guidelines for entrepreneurship; and
6. list three controls that regulate the free enterprise system.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

economy
communism
socialism
capitalism
capital
entrepreneurship
regulation
partnership
corporation

investment
profit
stocks
competition
free enterprise system
supply and demand
sole proprietorship
business plan
financial plan

TEACHING AID

- Test Key: 1-C, 2-A, 3-B, 4-B, 5-D, 6-B, 7-A, 8-C, 9-C, 10-D

SUGGESTED REFERENCES

Fales, J., et al. Manufacturing: A Basic Text for Industrial Arts. Bloomington, Ill.: McKnight Publishing Co., 1980.

Wright, T. R., and Jensen, J. R. Manufacturing Materials Processing, Management, Careers. South Holland, Ill.: Goodheart-Willcox, 1976.

SENTENCE OUTLINE

I. Introduction
  A. Three types of ownership
    1. Sole proprietorship: Sole proprietorship is a single person owning a business.
    2. Partnership: Partnership means two or more people owning a business together.
    3. Corporation: Corporations are when shares of stock are sold to individuals and these individuals act as one to operate the business.
  B. All companies are organized in a certain hierarchial structure, with various line and staff functions and responsibilities.
  C. Entrepreneurship involves the functions of planning, organizing, controlling, and directing workers and activities.

D. It involves the feasibility of providing a product or service to the consumer at a fair price and of high quality.

E. Securing and training manufacturing workers for the business is a vital part of entrepreneurship.

F. Scheduling workers and routing materials for the job is a major responsibility to the overall success of the business, and seeing that a job is completed on time with good workmanship is another.

II. What is communism? (examples: Russia and China)

A. This type of economic government is highly centralized with a small group of governmental leaders making major economic decisions for everyone.

B. The government owns the means to production (land, raw materials, factories, stores, transportation, etc.).

C. Communism and socialism are basically the same, except politically. Communism may favor revolution and force to spread its beliefs, whereas socialism advocates peaceful political change.

D. Entrepreneurships cannot exist in a highly centralized form of government where risk-taking is discouraged.

III. What is socialism? (examples: Sweden and Denmark)

A. Socialism is similar to communism where the means of production are owned by the government and a small group of leaders determine what, when, and how much to produce.

B. Advocates of socialism believe in peacefully blending their belief into society.

C. Most socialist states are mixed, allowing capitalism to coexist.

D. Entrepreneurship can flourish in a mixed socialist and capitalist state, but cannot exist in a purely socialist country.

IV. What is capitalism? (examples: United States and Canada)

A. **Capitalism** is an economic system which stresses private economic decision making and operates without an overall grand economic plan which is common to the communist and socialist economic systems.

B. Capitalism is based on **capital,** or the surplus money of a company or individual.

C. Capital is **invested** by individuals or companies with the hope of making more money.

1. An individual may invest capital in a bank that pays **interest,** or take more of a risk and invest it in **stocks,** which provide capital to companies.
2. A company may invest its capital in new machines and facilities to produce more, better, or new products in hopes of making a **profit,** or more money from its capital.

V. The free enterprise system and entrepreneurs

A. The industrial system in the United States is known as a free enterprise system, and individuals and companies are free to make nearly any product they wish.

B. The free enterprise system encourages individuals and companies to become entrepreneurs.

C. Entrepreneurs are risk-takers who invest capital to produce products with the hope of making a profit.

D. The free enterprise system is controlled by the laws of **supply and demand, competition,** and **regulation.**

1. Supply and demand: when demand is high for a product, entrepreneurs are willing to invest capital to produce more of a product, but a high supply of a product discourages entrepreneurs from investing capital.
2. Competition is also a characteristic of a free enterprise system. Competition allows for two or more companies to produce similar products and compete in the market place for the consumer's dollar. The company

that produces the best product, at the lowest price, usually makes the most profit.

  3. Regulations are set by the government and private agencies to control the type and specifications of a certain product. (For example, the Environmental Protection Agency (EPA) requires automakers to control the pollutants they emit into the environment, or the Food and Drug Administration (FDA) requires that new medicines placed on the market be safe.)

VI. Becoming an entrepreneur
- A. An enterprise is any business that sells either products or services, or both, and is owned, managed, and controlled by one or more persons.
- B. All enterprises carry with them basic risks.
  1. There are no guarantees of success.
  2. There are no guarantees of making a profit.
  3. There are no guarantees that you will avoid losing your investment.
- C. Private enterprise in America is a privilege of our economic system.
- D. Our entire business system is made up mostly of small, privately owned companies.
- E. Our marketing system, and competition within the markets for products and services, is the strength of America.
- F. Our system is efficient because competition forces individual owners to streamline, cut waste, improve products and their services, and place the consumer or customer at the top of the economic pile.
- G. Entrepreneurship lets you decide your own destiny.
- H. The entrepreneur's keys to success are how well you manage what you have and how well you plan.
- I. Entrepreneurship provides challenge and personal satisfaction.
- J. Satisfaction is knowing that you provide a valuable service to customers and make their lives better.

VII. The dangers and pitfalls to avoid
- A. Owning and managing a business requires great personal sacrifice.
- B. Ownership requires serious responsibilities.

VIII. Guidelines for entrepreneurship
- A. Get the right kind of assistance.
  1. Seek literature, publications, periodicals, textbooks, and other resources that give advice and essential knowledge.
  2. Visit the Small Business Administration offices.
  3. Talk to a local banker.
  4. Practical experience can be gained by working in the kind of business you wish to operate.
- B. Prepare a plan.
  1. You need a business plan.
  2. You need a marketing plan.
  3. You need an operating (profit-and-loss) plan.
  4. You need an organization and staff plan.
  5. You need job descriptions and responsibilities assigned to functions.
- C. Get the financial assistance you need before you start.
  1. You need a good credit rating.
  2. You must know what you want to do.
  3. You must have a good plan.
  4. You must demonstrate good management and financial responsibilities.
  5. You need a good balance between personal assets and borrowing funds.

D. Get professional marketing assistance.
   1. A competent commercial real estate agent can help you choose a good location, lease a building, buy an existing business, or perhaps develop a new business in a new location.
   2. You need an expert accountant to help you plan your finances, maintain your records, and set up the right kinds of ledgers and accounts, interest rates, equipment purchases, employee records, tax reporting, and business planning.
   3. You need a competent attorney to help you plan the legal forms of ownership of your business, negotiate contracts and leases, get the right kinds of licenses and permits, and types of liabilities you assume.
   4. You need help of the local chamber of commerce or merchants association.
   5. You need to join a professional trade association.

IX. Planning your business
   A. Financial planning: The Bank of America suggests that an entrepreneur begin by asking four questions.
      1. What do I need the money for?
      2. How much money do I need?
      3. How and when can I repay the money borrowed?
      4. Can I afford to borrow money at this time?
   B. Business plan: A good plan has seven parts.
      1. Description
      2. Market analysis
      3. Product and service description
      4. Sources of supply
      5. Marketing plan
      6. Management plan
      7. Financial forms

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook

SUGGESTED STUDENT ACTIVITIES

1. Select particular stocks from the newspaper, and follow their activity for a month. Determine if a profit or loss has been made.
2. Research the three economic systems—communism, socialism, and capitalism.
3. Discuss the differences between communism, socialism, and capitalism.
4. Class officers will conduct a meeting to decide which product or service will be of economic value to the class or AIASA. The class will work as a group to form an enterprise. An enterprise committee will organize the technical and financial details for the class members. The entire class will work to make a profit for the class or to pay for AIASA dues or other activity.
5. Have students build a product of their choice. This product may fulfill a personal need, be for a family member, and be sold to someone in the community. Students should show a profit for their efforts. Compare this type of enterprise with that in activity No. 4.
6. Have a real estate agent, an accountant, and a banker serve on a panel to discuss business and financial planning with the class. This should be done through an AIASA activity.

Vocabulary Worksheet

(Entrepreneurship)

1. economy
2. communism
3. socialism
4. capitalism
5. capital
6. entrepreneurship
7. regulation
8. investment
9. profit
10. stocks
11. competition
12. free enterprise system
13. supply and demand
14. sole proprietorship
15. partnership
16. corporation
17. business plan
18. financial plan

TEST

UNIT 4/SECTION B: ENTREPRENEURSHIP

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. This type of economy has an overall grand plan for what will be produced and for who owns the means of production:
A. capitalism
B. socialism
C. communism
D. all of the above

___ 2. This economic system, due to its lack of governmental control, strongly encourages entrepreneurship:
A. capitalism
B. socialism
C. communism
D. all of the above

___ 3. Capital is--
A. money needed for basic survival needs of food, shelter, or clothing
B. surplus money an individual or company can use to invest
C. money put into a savings account
D. money that is needed to live on

___ 4. An entrepreneur--
A. can do well in a communistic country
B. is a risk taker
C. both of the above
D. none of the above

___ 5. What controls determine what will be produced in a free enterprise system?
A. supply and demand
B. competition
C. government
D. all of the above

___ 6. Stock is--
A. money put into a savings account
B. money invested in a company
C. money that is borrowed
D. none of the above

___ 7. Sole proprietorship is--
A. a single person owning a business
B. several people owning a business together
C. when shares of stock are sold to individuals and these individuals act as one to operate the business
D. none of the above

___ 8. A partnership is--
A. a single person owning a business
B. when shares of stock are sold to individuals and these individuals act as one to operate the business
C two or more people owning a business together
D. none of the above

___ 9. A corporation is--
A. a single person owning a business
B. several people owning a business together
C. when shares of stock are sold to individuals and these individuals act as one to operate the business.
D. none of the above

___ 10. A business plan only includes--
A. a market analysis
B. a product and service description
C. a management plan
D. none of the above

Section C: Laboratory Organization

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. explain the importance of an efficient management organization in industry;
2. complete an application form for a position of employment; and
3. identify and display the qualities employers look for in employees.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

application form
interview
supervisor

TEACHING AIDS

- Overhead projector
- Transparencies and Handouts: You will find transparencies MW4-3 through MW4-5 and Handouts No. 10 and 11 at the end of this unit. If you wish, these may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW4-3: Organizational System, Industrial Corporation
MW4-4: Organizational System, I. A. Laboratory
MW4-5: Qualities of Good Employees

Handout No. 10: Application for Employment/Hourly Personnel
Handout No. 11: Application for Employment/Salaried Personnel

SUGGESTED REFERENCES

Brown, R. D. Industrial Arts Laboratory Planning and Administration. New York: Bruce Publishing Co., 1969.

Chruden, H. J., and Sherman, W., Jr. Personnel Management. 5th ed. Dallas, Texas: South-Western, 1976.

SENTENCE OUTLINE

I. All successful industrial corporations operate within efficient organizational systems.
   A. A good organizational system is necessary to make sure all tasks are performed with minimal loss of time, money, and materials.
   B. Efficient organization increases productivity and profit.

II. In larger corporations, authority and responsibility are delegated by the board of directors to the president, vice-presidents, managers, and supervisors. (Transparency MW4-3)

III. Many management systems are used in industry with the line system being the most common.

IV. Industrial Arts laboratories can also benefit from the use of an efficient management system. (Transparency MW4-4)

V. The development of an efficient laboratory system involves:
   - A. A determination of all tasks to be performed on a regular schedule—daily, weekly, monthly, yearly.
   - B. A determination of who should perform the tasks—teacher, students, maintenance personnel, custodial staff.
   - C. A determination of how many students are needed to perform each task quickly and efficiently.
   - D. The development of a system for rotating the tasks from student to student periodically.
   - E. The development of an incentive plan to stimulate the students to perform the assigned tasks quickly, efficiently, and as well as possible.
   - F. The selection of reliable and qualified students to fill the positions of supervisor and assistant supervisor.

VI. Most people work better if they know they will be rewarded for work well done.

VII. Common rewards used in industry include:
   - A. An increase in wages.
   - B. A promotion to a position of higher authority.
   - C. Bonus time off from work duties.

VIII. Most industries use an employee selection process that includes:
   - A. The completion of an application form. (Handouts No. 10 and No. 11)
   - B. A personal interview with the prospective employee.

IX. During an interview for a prospective position, an applicant can improve the chances for employment by: (Transparency MW4-5)
   - A. Being well dressed and well groomed.
   - B. Being well prepared with intelligent questions about the responsibilities and duties associated with the position.
   - C. Having knowledge about the company, its products, and its operation.
   - D. Displaying the qualities employers look for, such as self-confidence, ambition, courtesy toward others, willingness to assume responsibility, honesty, and the ability to follow instructions and work with people.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)
- Application form

SUGGESTED STUDENT ACTIVITIES

1. Identify and discuss all the tasks in the laboratory that need to be performed on a regular basis (daily, weekly, monthly, yearly) which can be performed by students.
2. Complete an application form for the position of supervisor, including qualifications for the position and reasons for seeking the position.
3. Ask the teacher to interview you for the position of supervisor, and attempt to convince the instructor that you are the most capable person to fill the position.
4. Construct a mockup of a time clock or some other suitable system to facilitate the checking of roll at the beginning of lab and the completion of all assigned tasks at the end of the lab.
5. Identify and discuss incentives or rewards to motivate you and your fellow students to complete your assigned tasks such as having one group on vacation through each rotation, added vacation time as a bonus for work well done, promotions, etc.

Vocabulary Worksheet

(Laboratory Organization)

1. application form

2. interview

3. supervisor

HANDOUT NO. 1

The Student Association as Personnel System with Uniform Titles

All Industrial Arts courses benefit from a personnel system used to manage the classroom or laboratory activities of students. Personnel management is a function of any organization whether it be a class of students, corporation of employees or an association of volunteers. Most Industrial Arts personnel systems differ as to the titles of each position in the system. Using AIASA related titles in the personnel system will both manage the class, as well as, give students experience with a group organization.

Officers in a democratic organization are best selected by the members of the group. Thus, the teacher may ask the class to nominate persons for election as key management officers. Teachers using any of the titles on the left are encouraged to utilize the uniform title in the right column.

Current Title	**Should Have This Uniform Title**
General Manager Lab Supervisor Superintendent Project Director	PRESIDENT
Manager's Assistant Assistant Supervisor Co-Director Production Manager	VICE PRESIDENT
Roll Keeper Recordkeeper Letterwriter	SECRETARY
Accountant Purchasing Agent Supply Clerk Bookkeeper	TREASURER
Safety Director Attorney or Lawyer Contract Officer Permission Coordinator Inspector	PARLIAMENTARIAN
Clean-up Supervisor	SERGEANT-AT-ARMS
Public Relations Director Advertising Agent Publicity Director	REPORTER
Education Director Final Report Writer Scrapbook Manager Librarian	HISTORIAN

HANDOUT NO. 2

AIASA PERSONNEL IN-CLASS DUTIES

PRESIDENT (Students Name)

1. Leader of personnal system.
2. Calls clean-up.
3. Conducts class meetings.
4. Receives ideas and reports from the class members.
5. Suggests any possible lab improvements gained through experience.
6. Responsible for the assignment or election of new personnel.

VICE PRESIDENT (STUDENTS NAME)

1. Familiar with duties of President.
2. Substitutes for President.
3. Assists President as second level manager.
4. Helps follow-up committee work.
5. Helps other officers if absent or behind.
6. Makes organizational chart for class.

SECRETARY

1. Takes roll, makes slip of those absent for teacher.
2. Keeps Minutes of class decisions for reading at next meeting.
3. Records list of officers and committee personnel.
4. Prepares agenda for seminar or class meetings.
5. Sends letters when necessary.

TREASURER

1. Collects routine fees or AIASA dues.
2. Checks names of students who pay and writes receipt.
3. Charge students for use of supplies.
4. Helps teacher order supplies.
5. Cleans supply room.
6. Reports progresses of supply payment or purchases at meetings.
7. Serves on Enterprising Committee of class.

PARLIAMENTARIAN

1. Is responsible for general safety procedures.
2. Posts safety posters and information.
3. Files safety test records.
4. Inventories first aid supplies and notifies instructor when additional supplies are needed.
5. Reports any injuries to the instructor.
6. Helps President with motions and rules of class.
7. Serves on School/Community Service Committee of class.

SERGEANT AT ARMS

1. Oversees all clean-up personnel.
2. Makes substitutions for absent clean-up personnel.
3. Improvises and receives ideas for improving clean-up.
4. Reports to President and teacher when the clean-up is completed.
5. Prepares room for class meetings.
6. May serve as Quality Control or Union Steward.

REPORTER

1. Reports to class on the progress of activities.
2. Prepares bulletin board or displays related to class activities or school AIASA.
3. Writes articles or makes photos for school newspaper.
4. Welcomes visitors and explains classwork.
5. Cleans darkroom if available.
6. Advertises projects or services of class.
7. Serves on Recognition Committee of class.

HISTORIAN

1. Picks up homework or assignments for teacher.
2. Checks off work turned in by class members.
3. Assembles group reports.
4. Keeps notebooks, files or scrapbook up-to-date.
5. Cleans books and reference area of class during cloud
6. Photographs activities.
7. Serves on Industrial Resource Committee of class.

HANDOUT NO. 3

COMMITTEE DUTIES

LABORATORY MAINTENANCE/ CLEANUP COMMITTEE	1. Sgt. at arms and officers appoint or rotate personnel to each position. 2. All students in class have duties or either as leader or worker in one of these areas: (1) Supplies and reference materials (2) Tools, equipment and machines (3) Auxiliary Rooms (4) Others (determined by teacher) 3. Workers report completion of duties to chairperson, leader, or sgt. at arms. 4. President, Sgt. at arms or teacher dismisses class at proper time.
INDUSTRIAL/COMMUNITY RESOURCE COMMITTEE	1. Make list of industrial or community resources related to course. 2. With teacher, select 3 helpful to unit of study. 3. Report resources available at class meetings for vote. 4. Arrange speakers or visits for class. 5. Send thank you letters.
SCHOOL/COMMUNITY SERVICE COMMITTEE	1. Make list of classroom, school or community service projects related to course. 2. With teacher, select 3 related to technical unit of study. 3. Review requests from others for services. 4. Report possible projects at class meetings for vote. 5. Organize class for work to be done. 6. Deliver service to appropriate person or group.
ENTERPRISING SERVICE OR PRODUCT COMMITTEE	1. Make list of products or services of economic value related to course. 2. Make prototypes of those related to unit of study. 3. Report possible products or services to class meetings for vote. 4. Organize company for production or service enterprise. 5. Keep financial records and report to class. 6. Present income for AIASA purpose to Treasurer.
RECOGNITION OF ACHIEVEMENT COMMITTEE	1. Make list of regular AIASA contests and others related to course. 2. With teacher, select or develop contests related to unit of study. 3. Report at class meetings on contests to be used. 4. Organize contest procedures and awards to be given. 5. Recognize winners with awards and newspaper articles.

HANDOUT NO. 4

In-Class Meeting Procedures

Many of the routine activities of an industrial arts class can be handled by the officers of the class's student association. The **Class Meeting Agenda** should be in front of the students as poster to help each student understand meeting procedures.

1. Call to Order

President: Raps gavel twice before saying - Will the (class or meeting) please come to order? Sergeant At Arms, are there enough members present and in their seats to have a meeting?
Sgt. at Arms: There are, (Mr. or Miss) President. Tells students who arrive late to see Secretary for roll check.

2. Hear the Minutes of the Previous Meeting

President: We are ready to transact our business. Will the Secretary please read the Minutes?
Secretary: The Secretary stands and reads the Minutes which include date, time and place motions and other details of the last meeting.
President: After the reading of the Minutes asks: Are there any corrections or additions to the Minutes? (If none, the Minutes stand approved as read, or the Minutes stand approved as corrected.)

3. Hear Reports of Officers or Standing Committees

President: The Assembly will hear reports of Officers. (After each report, may ask; You have heard the report. What is your pleasure? For approval or adoption by motion?
Treasurer: The following amounts have been paid as (fees or dues) to the Treasurer $__________.
The amount of $________ has been paid out. The total balance is $________.
The Treasurer may announce any fees to be paid or information about supplies.
Historian: (May call for homework or assignments as part of group effort.)
Sgt. at Arms: (May report on clean-up changes and condition of classroom and laboratories.)
Parliamentarian: (May report or advise on procedures used for meeting or laboratory safety.)
Secretary: (May report attendance information and give list of absent students to teacher.)
President: Do any Committees have reports?
Maintenance Comm: May report or advise.
Service Committee: May report or advise.
Enterprising Comm: May report or advise.
Resources Comm: May report or advise.
Recognition Comm: May report or advise.
President: After each report say, You have heard the report. What is your pleasure?

4. Hear Reports of Special Committees

President: We will hear the report of the special committee for ____________________.
Special Comm: May report or advise.
President: You have heard the report. What is your pleasure?

5. Hear Announcements

President: Are there any announcements to be made at this time?
Reporter: May report on class progress or outside events of interest to class or school AIASA.
Open to the Floor: Other students may announce any meetings, activities or events scheduled in the future.
Teacher: May wish to make announcements also.

6. Unfinished Business

President: The floor is open for discussion of unfinished business of the last meeting.
Secretary or Parliamentarian: May call attention to tabled motions or details from minutes of previous meetings.
Historian: May remind members of homework or reports assigned or collect papers for teacher.

7. New Business

President: The floor is open for discussion of new business.
Open to the Floor: Suggestions for action not discussed before at the meeting would be introduced.
President: (When the President feels that the discussion is complete, ask:) Does anyone desire to make a motion? (President acts on motion, appoints a committee or calls for another new business, or may call on the teacher (Mr., Miss, Mrs. ________, do we have a lesson?)
Teacher: Presents lesson or announces laboratory work.

8. Adjournment of the Meeting

President: Raps gavel twice. If there is not further business, the meeting stands ready to adjourn.
Raps gavel 3 times. What is our motto?
All: "Learning to Live in a Technical World."
President: Does anyone wish to introduce a motion to adjourn? (Conduct vote on motion and declare adjournment) or say; Does anyone know of any reason why this assembly should not adjourn?
I declare this meeting adjourned.

HANDOUT NO. 5

HOW MOTIONS ARE MADE

HOW TO PRESENT A MOTION

There are eight simple steps in presenting a main motion:

1. The member rises and addresses the President.
2. The member is recognized by the President.
3. The member states his idea as a motion.
4. Another member seconds the motion.
5. The motion is restated by the President.
6. The Presidents conducts the discussion.
7. The President puts the question to a vote.
8. The President announces the result.

The main motion forms the starting point for any action to be taken by the group. Informal discussion may be allowed in small groups, but to be considered, the motion must be made, seconded, and stated by the President.

The President should know the exact moment at which to stop any informal discussion. He may bring things to a head by saying:
"If definite action is sought in this matter, a motion is in order."

This is how a motion is made:

1. Stand and address the President: **"Mr. or Ms. President."** Wait until you are recognized by the President. Do not speak until you are recognized by a nod or by name.

2. Be sure you have your motion clearly in mind, and worded as briefly as possible. Write it out if you can.

3. When you have been recognized, state the motion so that all can hear: **"I move that this chapter give a rising vote of thanks to its sponsor, Mr. Gardner."**

4. After the motion has been made, another member, without waiting to be recognized, calls out: **"I second the motion."**

5. The motion having been made and seconded, the President states the motion by saying: **"It has been moved and seconded that this chapter give a rising vote of thanks to its sponsor, Mr. Gardner."**

6. When the chairman has stated the motion, it is said to be pending. It may now be considered by the group — that is, it is open to discussion and debate.

7. Any member may now rise to agree or disagree with the proposal. For example, a member may rise and say: **"Mr. or Ms. President."** The President says: "Ron," so giving him permission to speak. **"I agree with the motion. Mr. Gardner has given his time to us and we should express our gratitude to him."**

8. The President inquires: **"Is there any further discussion?"** Since no one rises to discuss the motion further, the President asks, **"Are you ready for the question?"** (The "question" is the vote.) The members call out, **"Question?"**

9. The President then puts the question — that is, he takes the vote. He or she says: **"It has been moved and seconded that this chapter give a rising vote of thanks to its sponsor, Mr. Gardner. All those in favor of the motion say 'Aye.'"**
   The members in favor of the motion say, **"Aye."**
   The President then says: **"Those opposed, say 'No.'"**

10. The President then announces the vote: **"The Ayes have it. The motion is carried."** Or, **"The Noes have it. The motion is defeated."**

KINDS OF MOTIONS

There are four kinds of motions:

1. Privileged motion
2. Subsidiary motion
3. Incidental motion
4. Main motion

Motions that concern the rights and privileges of members are called privileged motions. Because of their urgency and importance they come before all other motions. The most common privileged motions are:

1. To fix time and place for adjournment.
2. To adjourn.
3. To take a recess.
4. Matters of personal privilege.
5. Orders of the day.

You will notice that four of these motions concern general rights. They are rights reserved to the chapter: when to adjourn, when to recess and when to insist that the rules be followed. The other motion, the motion of privilege, is the most important. It refers to a member's individual and personal rights.

Let us take an example of how this motion actually works.

Whenever there is any disturbance to the assembly, such as noise, presence of non-members, quarrels between members, or unpleasant atmospheric conditions, like excessive heat or cold, you may rise to a question of privilege. Suppose there is so much noise that you cannot hear. You might stand, and without waiting to be recognized, say: **"Mr. or Ms. President, I rise to a point of personal privilege."**

The President would then tell you to state your point of privilege. You might say, **"There is too much noise. I can't hear."**

Motions of personal privilege require no second, and are immediately decided by the President. In this case, he/she might direct the speaker to talk more loudly or he might take some other measure, such as closing the windows to shut out the disturbance. Business would then be resumed.

Subsidiary motions amend or otherwise dispose of other motions. There are seven of them. The two you may want to use, however, are (1) to refer to a committee, and (2) to amend.

You use the refer to a committee motion whenever you feel that the chapter should study the proposition more carefully before voting on it. You rise and say, **"Mr. or Miss President."**

When recognized, you then say: **"I move that this question be referred to a committee."**

This motion must be seconded. It can be amended. It can be debated. It cannot be reconsidered once the committee has begun its study. It requires a majority vote.

The motion to amend seeks to modify or change the motion under consideration. When you wish to make it, you must rise and say, **"Mr. or Ms. President."**

When you have been recognized by the President, you might say, **"I move to amend the motion by striking out the word 'annual.'"**

When you make this motion, you must be sure to state definitely the way in which you want the amendment made.

Motions that arise out of debate are called incidental motions. They are concerned with small matters that can readily be settled. For example, a member desires to know some matter of information (point of information) or a member desires to question a vote (divide the assembly), or a member desires to know if the proper procedure is being followed (point of order).

A main motion brings a new proposal before the chapter. It is only in order when no other main motion is being debated.

A main motion is subject to six conditions:

1. It must be seconded.
2. It can be amended.
3. It can be debated.
4. It can be reconsidered — that is, brought up a second time.
5. It can have additional motions that change it.
6. It requires a majority vote

HANDOUT NO. 6

DUTIES FOR IN-CLASS USE OF COMMUNITY RESOURCES

This activity will help students learn how to invite and properly use a guest speaker in the Industrial Arts class. The particular content of the course or lesson will determine the type of resource person who should be contacted. The student learns to call, talk with, write letter, and introduce a speaker as part of classroom instruction.

Officer and Committee Duties

Community Resources Committee:	This committee of the class meets often during the semester to find ways for industry and community resources to be used for the Industrial Arts class or laboratory. Types of resources include speakers, field trips and laboratory materials which help class with chosen activity. Teacher may suggest possible speakers related to technical or career aspects of the course.
President:	Opens meeting to hear report of Community Resources Committee and involve class in deciding resources for class to use. Relatives, friends, industrial workers or business leaders may be suggested by class members. Class votes to use a resource in cooperation with teacher and school office.
Vice-president:	May prepare sample questions for class members to ask speaker.
Secretary:	Records suggested names of community resources and records any decisions made by class.
Treasurer:	Most speakers will not require any financial assistance; however, if near lunch period the class may ask person to stay for lunch at school.
Parliamentarian:	Helps class use proper procedures for inviting, talking to and thanking a resource speaker.
Reporter:	Assures speaker will be met by committee or officer. Obtains information about speaker to announce to other teachers if appropriate.
Sgt. at Arms:	Assures speaker is not interrupted while talking with class.
Historian:	Records or videotapes speaker so speech can be saved for use with other classes.

TYPICAL SCHEDULE FOR USING A SPEAKER

class Meeting 1.	Teacher explains that there are various resource persons in the community who could speak to the class and help them learn additional information.
2&3.	Students survey community for resources related to the topics of the course.
4.	Industrial/Community Resource Committee reports to class on those resource person they have considered good for the course content. Class officers conduct meeting of class to vote on one person to invite to speak.
5.	Committee writes letter to invite resource person giving dates suggested by teacher and with approval of principal's office.
6&7.	Committee prepares questions and gathers information related to speaker or the industry.
8.	Teacher follows up letter by calling the speaker to discuss dates, times, topic and school policies related to outside speakers.
Day of Speaker –	Committee meets speaker at arrival time and introduces speaker to principal, teacher and class. (Other teachers or classes may also attend.) Class members ask questions at appropriate time. Other committees or groups may seek advice on their activities or projects using the resource person as a consultant.
After speech	Reporter writes news story about speaker and talk. Thank you letter is written to speaker. Recordings of speech are shared with other classes or information is filed so that speaker can be invited again.

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DUTIES FOR IN-CLASS SERVICE PROJECTS

This activity will use the procedures of the "Group Project" method which begins on Page 40 of the Exploring Technology Guide. This method uses "student involvement, interaction and skills to produce one or more tangible products . . ." Leadership and fellowship are developed as students work together in the laboratory as one industry to produce a product.

Officer and Committee Duties

Service Committee:	Meets to screen or encourage and select a service project for the class to build.
President:	Opens meeting to hear report of Service Committee and involve class in decision. Class votes on service to be provided to another group.
Vice-president:	Reproduces organizational chart for group project system and asks class to determine who will take each position.
Secretary:	Keeps minutes of class meeting and records names of students who are members of group project.
Treasurer:	Advises class on financial details related to service project.
Parliamentarian:	Advises class on proper procedures for obtaining permission.
Sgt. at Arms:	May suggest services or improvements needed within laboratory such as tool holders or safety devices.
Reporter:	Writes story about plans of class to build a service project to help others. Takes photos of work and delivery for story.
Historian:	May share information on previous projects related to this one. Keeps records for other classes to use for reference.

TYPICAL SERVICE PROJECT SCHEDULE

Class Meeting 1. Teacher explains group project method to class and students discuss possible service projects for Service Committee to consider.

2. Service Committee reports to class a recommended service project and class selects project to build.

3. Class Vice-President distributes organizational chart for Group Project and may have students apply for positions.

4. Students report during seminar on role or duties they hold in Group Service Project. Research and Design Directors work to determine specifications and prepare drawings.

5. Students apply for jobs in the organization.

6, 7 & 8. Teacher may demonstrate technical areas related to project selected as needed in construction.

9. Students use laboratory to build sub-parts of project.

10. Reporting seminar permits students to present work completed or problems solved.

11. Students use laboratory to assemble or complete project.

12. Reporter and Historian write stories for public information.

13. Teacher evaluates each student's participation as to technical knowledge gained and interest in helping others.

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HANDOUT NO. 8

DUTIES FOR IN-CLASS ENTERPRISING PRODUCTS

This activity will use the procedures of the "Line Production" method which begins on page 40 of the **Exploring Technology Guide**. The method is used "to acquaint students with: the ways in which contemporary industry organizes people, materials, and machines into a common endeavor; the study of occupations related to areas of management and labor within industry . . ." The student learns to develop a company, solve management problems and realize profits from a salable product or service.

Officer and Committee Duties

Enterprising Committee:	This committee of the class meets separately to design or select products or services to enterprise for a profit. May use criteria for product selection, sketches or mockups. Organize sales training for all class members such as: Making sales presentations, taking orders and keeping records of sales contacts made, good manners and courteous behavior.
President:	Opens meeting to hear report of Enterprising Committee and involve class as Board of Directors in deciding what product to make and how profit will be used after product is sold.
Vice-President:	Reproduces an organizational chart of a company and sample personnel roles for distribution to students.
Secretary:	Records information decided by Board of Directors and result of voting for General Manager in the company.
Treasurer:	Helps determine financial needs of class and determine capital needed to begin production. Suggests recordkeeping system for enterprise.
Parliamentarian:	Prepares mock incorporation papers for the company and obtains approval from school officials with teacher.
Sgt. at Arms:	Assigns cleanup duties appropriate to production activity of class.
Historian:	Files records and samples of every phase of activity for other classes to use.
Reporter:	Selects or makes promotion materials to advertise product or service to school.

TYPICAL ENTERPRISING PRODUCT SCHEDULE

Class Meeting 1. Teacher explains line production method that class will use to raise funds for activity they select.

2. Enterprising Committee reports to class showing sketches or mockup models of products which could be produced and sold. Class votes on product and activity as the Board of Directors.
3. Vice-President distributes organizational chart for company. Class votes for person to lead as General Manager.
4. General Manager selects second line management and the Personnel Director to hire all other employees.
5. Design Engineer presents drawings to class and will prepare a very accurate prototype with the help of the production and industrial engineering departments.
6. Assess school for product sales appeal.
7. Each person will report on completed duties accomplished in the role held.
8. Personnel Manager will assign students to make necessary jigs and fixtures.
9. Assign students to work stations and try out a test run.
10. Production of products on assembly line.
11. Advertising personnel will design and produce posters and order forms for product sales.
12. Prepare a marketing management system to control products. Record who is contacted and sales information.
13. Deliver product to customer.
14. Account for all purchases, sales and losses.

HANDOUT NO. 9

DUTIES FOR IN CLASS CONTESTS OR RECOGNITION

This activity will involve students in contests which are provided at local, regional, state and national conferences. Thus, students may practice and compete in tool identification, prepare an exhibit or give a speech as part of the way they are learning Industrial Arts. The teacher should suggest these contests to the Recognition Committee that relate to the course the students are taking.

Officer and Committee Duties

Recognition Committee:	This committee of the class meets to determine what contests relate to class and study rules for possible contests to be held in class or laboratory.
President:	Opens class meeting to hear report of Recognition Committee and involve students in selecting contest for class to use.
Vice-President:	Assists with organizational chart to show how students will compete.
Secretary:	Writes letters to persons who will be asked to serve as judges.
Treasurer:	Assists in determining and purchasing awards to be given to winners.
Parliamentarian:	May help select judges for contests and review rules for participation.
Sgt. at Arms:	May assist judges in keeping order or use of rules.
Reporter:	Writes up news stories about contests, exhibit or demonstration and announces winners. May invite community or other students to see contests.
Historian:	Keeps records of each activity and files records or photos for future reference.

DUTIES FOR IN CLASS OPEN HOUSE EXHIBITS

This activity will involve students in gaining recognition for their achievements in this industrial arts course. The officers of the class will assist with the activity and every student will not only help but will also contribute projects to be exhibited.

OFFICER AND COMMITTEE Duties

Recognition Committee:	This committee of the class meets to determine what type of Open House will be appropriate to the course and works with teacher to arrive at the best date.
President:	Opens class meeting to hear report of the Recognition Committee and involve class members in the decisions related to the Open House.
Vice-President:	Assists with the organizational procedures and work assignments of committee members and officers.
Secretary:	Writes letters or helps with invitations send to school personnel and others class wants to invite.
Treasurer:	Records expenses incurred during the Open House activity and seeks funds to meet these costs.
Parliamentarian:	Makes sure that proper procedures are followed as visitors are invited or other arrangements are made within the class or school.
Sgt. at Arms:	May assist committee in setting up exhibit tables and arranging for or cleaning up after open house.
Reporter:	Helps to publicize the Open House around the school. Takes photos and writes story before and after the event for the newspaper.
Historian:	Files and keeps information or photos of the event for use by future students.

SCHEDULES FOR RECOGNITION EVENTS

USING A CONTEST IN CLASS

1. Teacher presents idea and purpose of contest during class time.
2. Recognition Committee suggests possible contests for class to use.
3. Officers lead class meeting to decide of contest to be used.
4. Committee reviews or plans rules and organizes time schedule for individuals to compete.
5. Students practice during class or as homework.
6. Students or other judges select up to six finalists.
7. Finalists compete before judges and awards are presented to each.
8. Reporter and other officers carry out their duties.

ENTERING A CONTEST

1. Obtain and study contest guidelines or rule books.
2. Complete forms to pre-register in contest.
3. Mail forms to Spring Festival Contest Chairperson.
4. Prepare and practice for event in class, school and as homework.
5. Demonstrate to class and other school groups for judging or criticism.
6. Dress and conduct oneself appropriately for judging.
7. Appear at scheduled time for contest and awards program.

HOLDING AN OPEN HOUSE

1. Class decides if open house will be by class alone or request school AIASA to cooperate.
2. Obtain permission from school office date and place of open house.
3. Organize class members to help with various set-up details.
4. Announce to students how to enter projects for open house exhibit.
5. Send invitations to school personnel, parents and community resources.
6. Provide recognition for those who participate.

GIVING A TECHNICAL DEMONSTRATION

1. Select a technical topic which would interest or help other people.
2. Prepare research report or speech on the topic of demonstration.
3. Make models or assemble tools for demonstration.
4. Practice giving demonstration in class, school or as homework.
5. Arrange time and place to give demonstration such as State Fair, shopping mall or open house.
6. Dress and conduct oneself in professional way prior to and during demonstration.
7. Provide demonstration and answer questions of those who watched.

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HANDOUT NO. 10

REGIONAL, STATE, AND NATIONAL RECOGNITION EVENTS FOR INDUSTRIAL ARTS STUDENTS

TECHNICAL PERFORMANCE CONTESTS

- Architectural Drawing
- Engineering Drawing
- Electricity/Electronics
- Graphic Arts
- L.S.R.A.V. (model race cars)
- Leathercraft
- Photography
- Metal Machining
- Small Engine Trouble Shooting
- Tool and Machine Identification
- Woodturning - between centers
- Woodturning - face plate
- Screen Process Printing (hand cut film)
- Metric 500 Race

GENERAL CONTESTS

- General Knowledge Test
- Public Speaking Contests (prepared and extemporaneous)
- Chapter Team Contest
- Research Paper Entry Contest
- Safety Poster Entry Contest
- Technical Writing Contest

- Booth or Display Contests
- Co-Curricular Activity Exhibit
- Community Service Project Exhibit
- Scrapbook or Record Book Exhibit
- Fund Raising Project Exhibit
- Booth Exhibit

PROJECT EXHIBIT CONTESTS (enter by course title and course code)

- Exploring Technology
- Modern Industry
- Construction
- Manufacturing
- Communications Technology
- Materials and Processes Technology
- Power and Transportation Technology
- Architectural Drawing
- Basic Technical Drawing
- Electricity and Electronics
- Energy and Power
- Engineering Drawing
- Graphic Communications
- Metals Technology
- Woods Technology
- General Industrial Arts
- Industrial Crafts
- (for other titles see Spring Festival Permanent Rules)

CHECKLIST FOR CONTEST PARTICIPANTS

Directions: Performance and leadership contests are judged on the following aspects. To assist students to improve themselves for the contest these statements can be checked off by another person.

Technical Understanding

__________1. Accurate information used from books and research.
__________2. Impact or value of technology understood.
__________3. Safety procedures are used or described.
__________4. Information reviewed or approved by teacher.

Leadership

__________1. Leadership ability is exhibited.
__________2. Experienced as officer or participant in AIASA.
__________3. Voice and mannerisms are appropriate.
__________4. Assists with projects of class.
__________5. Helped arrange materials and forms for entry into contest.
__________6. Sent registration materials to contest chairperson.

Career Information

__________1. Knows at least 5 careers related to contest.
__________2. Understands requisites for career entry.
__________3. Lists programs for occupational preparation.

Performance

__________1. Shows interest and enthusiasm.
__________2. Dressed appropriate to contest.
__________3. Presents or demonstrates information in orderly manner.
__________4. Develops eye contact.
__________5. Voice and manner professional.
__________6. Paper organized well and holds interest.
__________7. Writing is accurate and to the point.

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HANDOUT NO. 11A

FMC Corporation An equal opportunity employer

Application for employment/Hourly Personnel

It is the policy of FMC Corporation to provide equal opportunity for all qualified persons and not to discriminate against any employee or applicant for employment because of age, race, creed, color, sex, national origin, or handicap.

Date

Return completed application to

PERSONNEL DEPARTMENT
FMC CORPORATION
FLUID CONTROL DIVISION
Stephenville Plant
2825 West Washington
P. O. Box 1377
Stephenville, Tx. 76401
817/968-2181

IDENTIFICATION

(Print) FIRST NAME MIDDLE NAME LAST NAME SOCIAL SECURITY NUMBER

LOCAL ADDRESS — STREET AND NUMBER TELEPHONE

PERMANENT ADDRESS — STREET AND NUMBER TELEPHONE

ARE YOU A U.S. CITIZEN? IF NO, WHAT TYPE VISA DO YOU HOLD?
☐ YES ☐ NO

NAME OF PERSON TO BE NOTIFIED IN CASE OF EMERGENCY CITY STATE ZIP TELEPHONE

PREVIOUS EMPLOYMENT

FROM	TO	NAME OF COMPANY	ADDRESS	POSITION	REASON LEFT	WAGE	May We Contact
			STREET ______ CITY ____ STATE ____				
			STREET ______ CITY ____ STATE ____				
			STREET ______ CITY ____ STATE ____				

PREVIOUS EXPERIENCE

CHECK MACHINES YOU HAVE OPERATED

___ Single Spindle Drill Press
___ Multiple Spindle Drill Press
___ Radial Drill
___ Automatic Screw Machine
___ Hobber or Gear Cutter
___ Turret Lathe
___ Molding
___ Engine Lathe
___ Bullard Boring Mill
___ Automatic Chuckers
___ Milling Machine
___ Horizontal Boring Mill
___ Boramatics
___ Iron Pouring
___ Universal Grinder
___ Internal Grinder
___ External Grinder
___ Cold Heading Machine
___ Punch Press
___ Swing Grinder
___ Core Making
___ Heat Treat Equipment
___ Lift Truck
___ Overhead Crane
___ Electric Welder
___ Acetylene Welder
___ Auto. Weld Machine
___ Foundry Laborer

OTHER MACHINES OPERATED ______

DO YOU SET UP ____ LAYOUT ____ READ BLUE PRINTS ____ MACHINE DRAWINGS ____ HAVE BASIC TOOLS ____

POSITION DESIRED ______ EARNINGS EXPECTED ______

SHIFT YOU CAN WORK: 1 2 3

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HANDOUT NO. 11B

Additional Experience

State what you did in any periods not already covered, including part-time or self employment - Additional sheets may be used.

Dates	

EDUCATION

NAME OF SCHOOL	LOCATION	Dates Attended		Years Credit	Year Grad.	Degree	Course or Major Subject
		From	To				
High School							
Business or Trade School							
College or University							
Other							

U.S. MILITARY SERVICE

Branch of U.S. Service	Date Entered		Date Discharged		Rank at Discharge
	Month	Year	Month	Year	

Nature of duties and any special training and honors received

Type of Discharge

Have you ever received a military disability pension? If so, give nature of disability

Present draft, reserve or military status

REFERENCES

NAME (not a relative or employer)	COMPLETE MAILING ADDRESS	OCCUPATION

REMARKS

Have you ever been convicted of, or entered a plea of guilty to a felony?

☐ Yes ☐ No If yes, explain fully.

List serious operations, accidents, illnesses, disabilities, and limitations (if none, so state)

Have you ever received Workman's Compensation for an industrial illness/injury? ☐ Yes ☐ No If yes, explain.

SIGNATURE

It is understood and agreed that any willful misstatement made by me in this application will be sufficient cause for discharge from the Company's service if I have been employed. It is also understood that this employment is subject to satisfactory completion of a physical examination by a company designated physician at the time of employment and at such time as may be required by the company.

Date ______________________________

Signature of applicant ______________________________

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HANDOUT NO. 11C

Work experience

If additional space is needed, attach separate sheets.

Present or last employment

Name of present or last employer
Type of business
Address
Starting date: Month / Year
Leaving date: Month / Year
Starting pay
Final pay
Reason for leaving
May we contact?
Job title (present or last)
Name of supervisor
Supervisor's job title
Description of work and responsibilities

Previous employment

Name of next previous employer
Type of business
Address
Starting date: Month / Year
Leaving date: Month / Year
Starting pay
Final pay
Reason for leaving
May we contact?
Job title (last)
Name of supervisor
Supervisor's job title
Description of work and responsibilities

Name of next previous employer
Type of business
Address
Starting date: Month / Year
Leaving date: Month / Year
Starting pay
Final pay
Reason for leaving
May we contact?
Job title (last)
Name of supervisor
Supervisor's job title
Description of work and responsibilities

Additional experience

State what you did in any periods not already covered, including part time or self employment

Dates

Unless otherwise indicated, state any prior work experience with FMC Corporation, its divisions or subsidiaries

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HANDOUT NO. 11D

Activities

Professional organizations, including offices (Omit union organizations and organizations which would indicate race, creed, color or national origin)	Hobbies and leisure interests

Publications

Title (include patents)	Journal reference or patent number

Work preferences

Kind of work most wanted

Other kinds of work in which interested

Location preferences or limitations	Approx. salary range expected	Date available to start work

Previous address

List home address in U.S. for last 5 years

Dates	Street and number	City	State	Zip

Remarks

Have you ever been convicted of a felony or misdemeanor other than parking or minor traffic violation?

☐ Yes ☐ No If yes, explain fully

List illnesses, disabilities, and limitations which may affect work performed or should be considered in determining job placement

Additional remarks relative to your candidacy

Signature

Date ______________________________

Signature of applicant ______________________________

It is understood and agreed that any wilful misstatement made by me in this application will be sufficient cause for discharge from the company's service if I have been employed. It is also understood that this employment is subject to satisfactory completion of a physical examination by a company designated physician at the time of employment and at such time as may be required by the company.

Form 808 – Rev. March 1977

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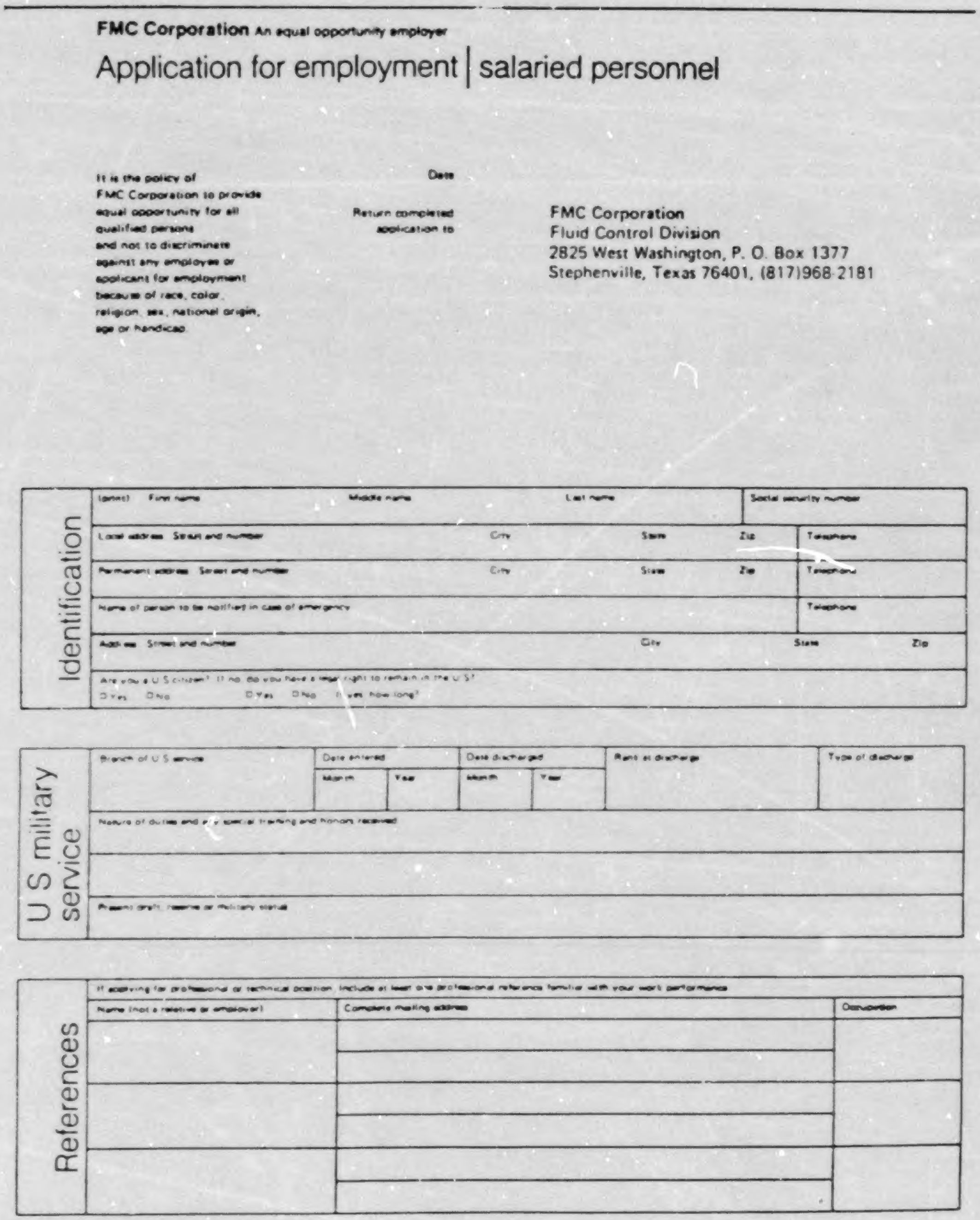
HANDOUT NO. 12A



FMC Corporation An equal opportunity employer

Application for employment | salaried personnel

It is the policy of
FMC Corporation to provide
equal opportunity for all
qualified persons
and not to discriminate
against any employee or
applicant for employment
because of race, color,
religion, sex, national origin,
age or handicap.

Date

Return completed application to

FMC Corporation
Fluid Control Division
2825 West Washington, P. O. Box 1377
Stephenville, Texas 76401, (817)968-2181

Identification

(print) First name	Middle name	Last name			Social security number
Local address Street and number	City	State	Zip		Telephone
Permanent address Street and number	City	State	Zip		Telephone
Name of person to be notified in case of emergency					Telephone
Address Street and number		City		State	Zip

Are you a U S citizen? If no, do you have a legal right to remain in the U S?
☐ Yes ☐ No ☐ Yes ☐ No If yes, how long?

U S military service

Branch of U S service	Date entered		Date discharged		Rank at discharge	Type of discharge
	Month	Year	Month	Year		

Nature of duties and any special training and honors received

Present draft, reserve or military status

References

If applying for professional or technical position, include at least one professional reference familiar with your work performance

Name (not a relative or employer)	Complete mailing address	Occupation

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Education and training

	Name of school	Location	Dates attended		Years credit	Year grad.	Degree	Course or major subject
			From	To				
Education	High school							
	Business or trade school							
	College or university							
	Graduate study							
	Other							
	Note: A copy of your college transcript should accompany this application if you graduated from college within last 5 years							

High school and undergraduate record		High school	College (undergraduate)	
	Scholastic standing (estimate if not known)	Average grade, standing in class, etc.	Average grade, gradepoint, standing, etc.	
	Scholastic honors		Significant courses in major subject if attended within last 5 years	
	Significant extracurricular activities if attended within last 5 years			
			Expenses earned (percent and how earned)	

Graduate study	Field of graduate study	Scholarships, fellowships, assistantships, etc.	Name of major professor
	Courses in specialized fields	Research problems	

Special training or qualifications	Languages spoken fluently	Languages read fluently	Factory or shop machines operated
	Office machines operated		
	Typing speed ____ wpm	Shorthand speed ____ wpm	
	Describe any other special training or skills which are in any way related to the kind of work you want to do		

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GENERAL DYNAMICS
Fort Worth Division
P. O. Box 748, Fort Worth, Texas 76101 (Mail Zone 1862)

APPLICATION FOR EMPLOYMENT

GENERAL DYNAMICS IS AN EQUAL OPPORTUNITY EMPLOYER AND
COMPLIES WITH ALL LAWS PROHIBITING DISCRIMINATION

DATE OF APPLICATION

GENERAL INSTRUCTIONS: It is important that you fill out this application blank thoroughly and completely. Please attach a supplementary sheet to this application with additional information if there is insufficient space provided under any of the entries below. A careful preplacement physical examination is required for all new employes, at which time consideration will be given to any physical condition which may have a bearing on placing you safely and suitably. This application must be filled out by you personally. Military discharge papers, birth certificate, and social security card are required at time of interview.

Name
(Last) (First) (Middle - No Initial)
☐ Male
☐ Female
Date of Birth
Height
Weight
Social Security No.

Present Address
(Number) (Street) (City) (State) (Zip Code) (Phone)

Permanent Address
(Number) (Street) (City) (State) (Zip Code) (Phone)

U. S. Citizen ☐ YES ☐ NO
If not a citizen, enter Alien Card No.

Do you have any relatives working at General Dynamics? ☐ YES ☐ NO (If "Yes", indicate name, relationship, division where employed)

Have you ever worked for General Dynamics? ☐ YES ☐ NO (If "Yes", indicate where, when, which division)

List ailments, physical defects, previous injuries (if none, write "NONE").

Have you ever been convicted for any violation of any federal, state, county, or municipal law? Include all courts-martial while in military service. Do not include traffic violations in which the only penalty was a fine of $25 or less. Write in YES or NO. __________ If "YES", give date, place, charge, and disposition in the following space. Attach sheet if necessary.

EDUCATION - Overflow information may be put on another sheet and attached (if college graduate, copy of college transcript or course outline would be helpful).

TYPE	NAME	LOCATION	MONTH & YEAR ATTENDED		MAJOR AND MINOR COURSES	DEGREES CONFERRED AND DATE
			FROM	TO		
HIGH SCHOOL						
COLLEGE OR UNIVERSITY						
TRADE SCHOOL OR OTHER SPECIAL TRAINING						

GRADE POINT AVERAGE - Undergraduate ____ Out of Possible ____
GRADE POINT AVERAGE - Graduate ____ Out of Possible ____
Approximate Rank in Class ____ of ____
Percent of College Expenses Earned ____ %
Graduate Thesis Subject

Extra Curricular Activities

Future Educational Plans

HANDOUT NO. 12C

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EMPLOYMENT RECORD List employers in the order in which you worked for them, showing most recent employer first. Include military service, periods of unemployment and self-employment, such as farming, etc.

FIRM NAME AND ADDRESS (GIVE COMPLETE ADDRESS)	MONTH AND YEAR EMPLOYED	POSITION AND DUTIES (More Complete Details May Be Furnished by Attaching Resume or by Utilizing Space in Remarks)	BASE RATE OF PAY	REASON FOR LEAVING
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		
Employer	Started		Starting	
Street Address				
City	Terminated		Ending	
State Zip Code		Supervisor		

May we question your present employer? ☐ YES ☐ NO	Will you work any shift? ☐ YES ☐ NO	Will you work overtime? ☐ YES ☐ NO	Will you work Saturday? ☐ YES ☐ NO	Will you work Sunday? ☐ YES ☐ NO

List type of work preferred

1.

2.

What is your minimum salary requirement?

Date available for employment

HANDOUT NO. 12D

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Have you ever been granted a security clearance? Answer Yes or No. ____________ If answer is "Yes" indicate level of clearance and where employed when cleared.

Have you ever had a security clearance suspended, denied, or revoked? Answer Yes or No. ____________ If answer is "Yes" where were you employed at that time?

Except for reasons of a reduction in force, have you ever terminated employment while a request or application for a security clearance was pending? Answer Yes or No. If answer is "Yes" where were you employed at that time?

REFERENCES - Six required - use full names.

All References Must Have Complete HOME Address NOT PROFESSIONAL Address

PROFESSIONAL - Previous supervisors preferred - If so, please indicate.

COMPLETE NAME	BUSINESS	COMPLETE ADDRESS

All References Must Have Complete HOME Address NOT PROFESSIONAL Address

CHARACTER - Do not list relatives or former employers.

COMPLETE NAME	BUSINESS	COMPLETE ADDRESS

MISCELLANEOUS - Overflow information may be put on another sheet and attached.

Technical Interest

Publications

Are you now, or have you ever been a member of, or affiliated or associated with any organization, association, movement, group or combination of persons (1) which advocates or advocated the overthrow of our Constitutional Form of Government, (2) which has or had adopted a policy of advocating or approving the commission of acts of force or violence to deny other persons their rights under the Constitution of the United States, or (3) which seeks or sought to alter the form of Government of the United States by unconstitutional means? ☐ YES ☐ NO (If "Yes," list name(s) of such organization(s), association(s), movement(s), group(s) or combination of persons.)

SOCIETIES AND ORGANIZATIONS - List all societies or organizations to which you have belonged in the last 10 years (if none, write "NONE"). Omit labor organizations or organizations which might indicate race, creed, color or national origin.

ORGANIZATION NAME	CITY	STATE	YEAR		OFFICES HELD
			FROM	TO	

ORGANIZATION NAME	CITY	STATE	YEAR		OFFICES HELD
			FROM	TO	

HANDOUT NO. 12E

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HANDOUT NO. 12F

FW86QCA1

VOLUNTARY INFORMATION

TO BE COMPLETED BY APPLICANT:

IN ORDER TO COMPLY WITH REPORTING REQUIREMENTS UNDER FEDERAL LAW, WE ASK YOU TO PLEASE COMPLETE THIS FORM. THE INFORMATION YOU ARE ASKED TO GIVE WILL BE USED SOLELY FOR PURPOSES OF COMPLIANCE WITH FEDERAL REQUIREMENTS. IT WILL NOT BE USED FOR HIRING, PLACEMENT OR ANY OTHER DECISION RELATING TO TERMS AND CONDITIONS OF EMPLOYMENT.

DO NOT HESITATE TO ASK FOR ASSISTANCE IF YOU HAVE ANY DIFFICULTY COMPLETING THIS FORM. THANK YOU VERY MUCH FOR YOUR COOPERATION.

PLEASE PRINT

LAST NAME	*FIRST NAME*	*MI*	*MO DAY YEAR* *APPL DATE*	*SEX* *Male* ____ *M* *Female* ____ *F*

RACE ________ *WHITE 0* ________ *BLACK 1* ________ *HISPANIC 2*

________ *ASIAN OR PACIFIC ISLANDER 3* ________ *AMERICAN INDIAN OR ALASKAN NATIVE 4*

HANDICAPPED *YES* ____ *NO* ____ *(Note 1)*	*VETERAN OF VIETNAM ERA* *YES* ____ *NO* ____ *(Note 2)*	*DISABLED VETERAN* *YES* ____ *NO* ____ *(Note 3)*	*MO DAY YEAR* *BIRTH DATE*

NOTE 1 – HANDICAPPED – "HANDICAPPED INDIVIDUAL" MEANS ANY PERSON WHO (1) HAS A PHYSICAL OR MENTAL IMPAIRMENT WHICH SUBSTANTIALLY LIMITS ONE OR MORE OF SUCH PERSON'S MAJOR LIFE ACTIVITIES, (2) HAS A RECORD OF SUCH IMPAIRMENT OR (3) IS REGARDED AS HAVING SUCH AN IMPAIRMENT.

NOTE 2 – VETERAN OF VIETNAM ERA – "VETERAN OF VIETNAM ERA" MEANS A PERSON WHO (i) SERVED ON ACTIVE DUTY FOR A PERIOD OF MORE THAN 180 DAYS, ANY PART OF WHICH OCCURRED BETWEEN AUGUST 5, 1964 AND MAY 7, 1975, AND WAS DISCHARGED OR RELEASED THEREFROM WITH OTHER THAN A DISHONORABLE DISCHARGE, OR (ii) WAS DISCHARGED OR RELEASED FROM ACTIVE DUTY FOR A SERVICE-CONNECTED DISABILITY IF ANY PART OF SUCH ACTIVE DUTY WAS PERFORMED BETWEEN AUGUST 5, 1964 AND MAY 7, 1975.

NOTE 3 – DISABLED VETERAN – A DISABLED VETERAN IS A PERSON ENTITLED TO DISABILITY COMPENSATION UNDER LAWS ADMINISTERED BY THE VA FOR DISABILITY RATED AT 30 PERCENT OR MORE, OR A PERSON WHOSE DISCHARGE OR RELEASE FROM ACTIVE DUTY WAS FOR A DISABILITY INCURRED OR AGGRAVATED IN THE LINE OF DUTY.

DO NOT WRITE BELOW THIS LINE

CONTROL NUMBER ☐☐☐☐☐☐☐ ROUTED YES ☐ NO ☐

CARD TYPE A

FUNCTON ☐

TO ☐☐☐☐☐☐☐☐

PRIMARY ☐☐☐☐ ☐

SECONDARY ☐☐☐☐ ☐ SOURCE ☐☐

EDUCATIONAL DATA

UNIVERSITY	DEG	DISC	GPA	QTL	MO	YEAR	MO	YEAR
					DATE		REL EXPER	

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RESIDENCES – List all your residence addresses for the past 5 years. If you were in the Armed Forces, list addresses just prior to entering (list most recent address first).

STREET ADDRESS	CITY	STATE	MONTH & YEAR		STREET ADDRESS	CITY	STATE	MONTH & YEAR	
			FROM	TO				FROM	TO

Draft Classification	Deferment Expires	Local Draft Board No. and Address

U.S. Veteran ☐ YES ☐ NO	Branch of Service	Date Entered	Rank	Type of Discharge	Date of Discharge	Rank

Member Reserve
☐ YES ☐ NO ☐ ACTIVE ☐ INACTIVE

If "YES", where?

Member Advanced R.O.T.C. Unit
☐ YES ☐ NO

If "YES", where?

How were you referred to General Dynamics?

In case of emergency notify (Name) (Address) (Phone No.)

REMARKS

I hereby certify that the answers by me to the foregoing questions and statements made are true and correct, without reservations of any kind whatsoever, and that no attempt has been made by me to conceal pertinent information. If employment is obtained under this application, I will willingly comply with all orders, rules, and regulations of this Company. I agree to submit to physical examination. I also authorize my former employers, schools, and personal references to give any information they may have regarding me, whether or not it is on their record. I hereby release them and their company from all liability for issuing same. It is understood that all facts are open to investigation by General Dynamics Corporation – and that if upon investigation, anything contained in this application is found to be false or misleading, I understand I will be subject to dismissal from employment at any time during the period of my employment and agree to hold General Dynamics Corporation and persons named herein blameless in that event.

Date (mo/day/yr)

DEPARTMENT 3
FWP 18547-80

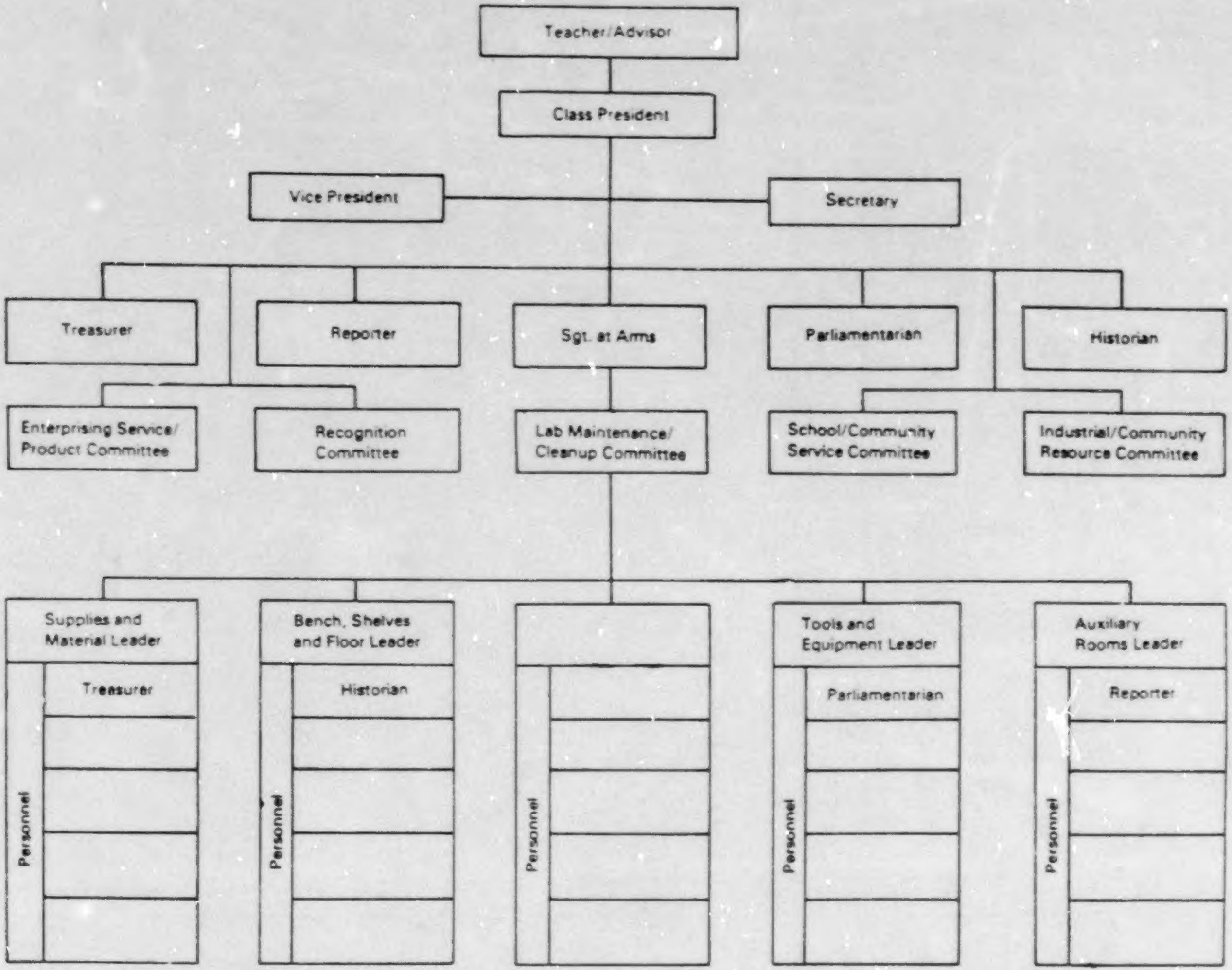
SIGNATURE OF APPLICANT

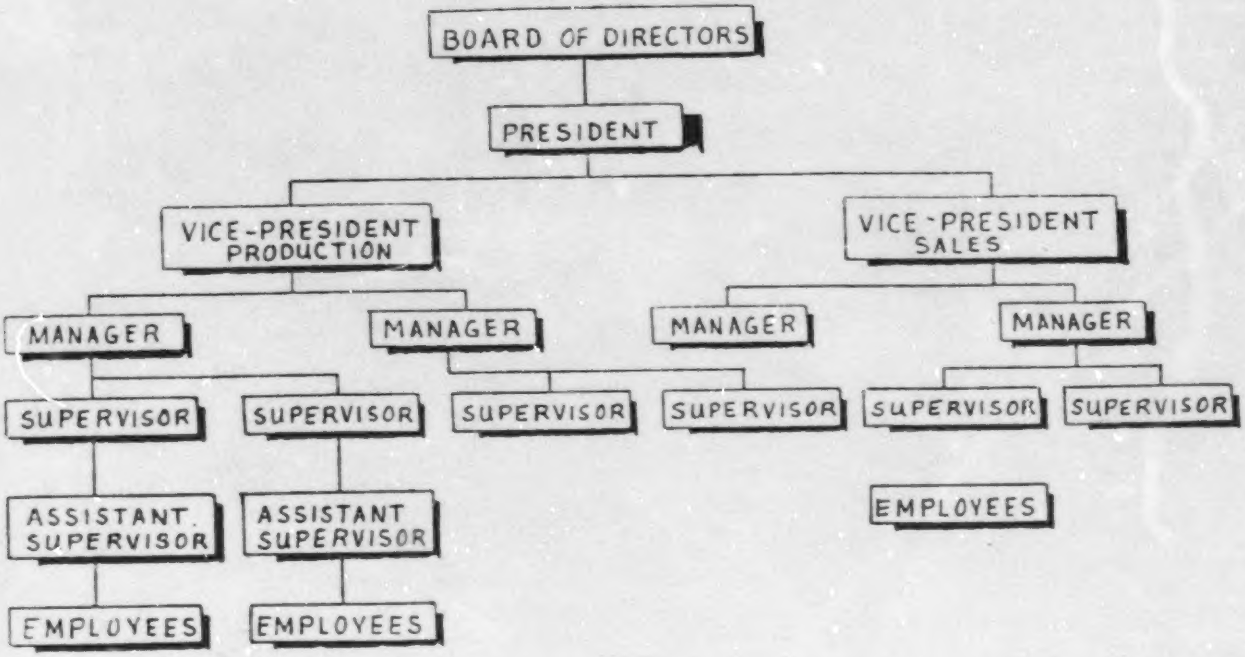
HANDOUT NO. 126

Calendar of Activities

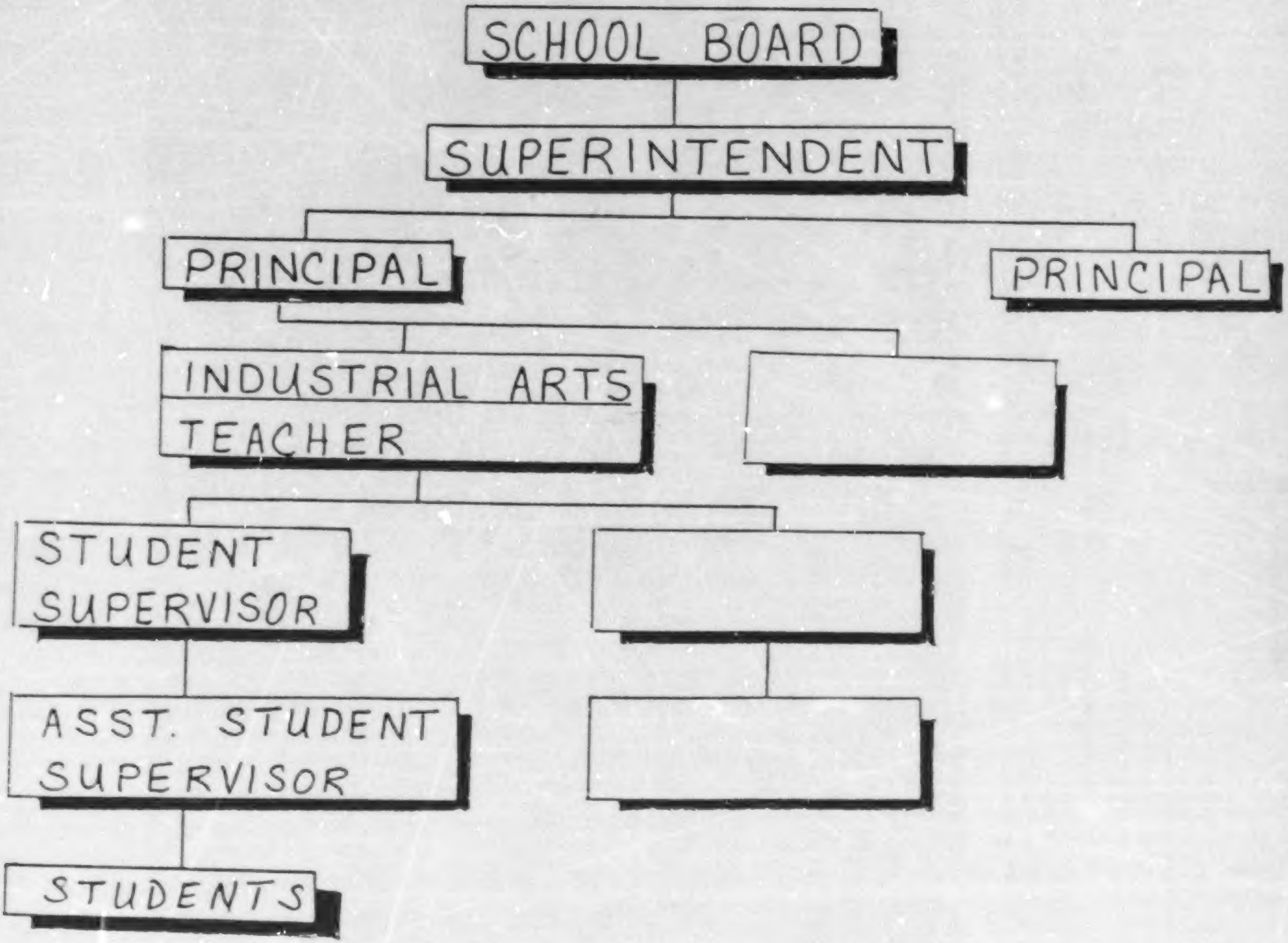
August	September	October
November	December	January
February	March	April
May	June	July

ORGANIZATIONAL STRUCTURE


Teacher/Advisor
Class President
Vice President
Secretary
Treasurer
Reporter
Sgt. at Arms
Parliamentarian
Historian
Enterprising Service/ Product Committee
Recognition Committee
Lab Maintenance/ Cleanup Committee
School/Community Service Committee
Industrial/Community Resource Committee
Supplies and Material Leader
Bench, Shelves and Floor Leader
Tools and Equipment Leader
Auxiliary Rooms Leader
Personnel
Treasurer
Personnel
Historian
Personnel
Personnel
Parliamentarian
Personnel
Reporter


BOARD OF DIRECTORS
PRESIDENT
VICE-PRESIDENT PRODUCTION
VICE-PRESIDENT SALES
MANAGER
MANAGER
MANAGER
MANAGER
SUPERVISOR
SUPERVISOR
SUPERVISOR
SUPERVISOR
SUPERVISOR
SUPERVISOR
ASSISTANT SUPERVISOR
ASSISTANT SUPERVISOR
EMPLOYEES
EMPLOYEES
EMPLOYEES

ORGANIZATIONAL SYSTEM
INDUSTRIAL CORPORATION

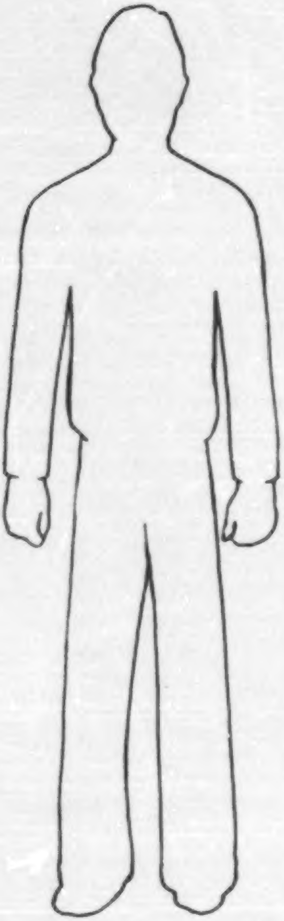

SCHOOL BOARD
SUPERINTENDENT
PRINCIPAL
PRINCIPAL
INDUSTRIAL ARTS TEACHER
STUDENT SUPERVISOR
ASST. STUDENT SUPERVISOR
STUDENTS

ORGANIZATIONAL SYSTEM I.A. LABORATORY

QUALITIES OF GOOD EMPLOYEES

RESPONSIBILITY

WORKS WELL WITH PEOPLE



AMBITION

COURTESY

FOLLOWS INSTRUCTIONS

CONFIDENCE

HONESTY

5

Material Layout

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. discuss important historical events concerning material layout;
2. judge products in relation to their function and design;
3. list the steps involved in the design process;
4. explain the relationship of function to design;
5. explain the influence that material has on the design of a product;
6. read blueprints;
7. understand drafting symbols related to metal work;
8. explain the difference between fractions, decimals, and metric measurements, and when and how each is used;
9. recognize orthographic multiview and pictorial drawings;
10. recognize the different types of lines on an industrial drawing;
11. define the various parts of a circle;
12. list the three forms of sheet metal pattern development, and explain when they are used;
13. develop a complete product plan;
14. add and subtract common fractions;
15. convert fractions to decimals, and decimals to fractions;
16. make linear measurements with a metric rule;
17. use the following layout tools: surface plate, scriber, dividers, rules, squares, combination set, swinging bevel, micrometer, calipers, various gauges and gages, machinist's hammer, punches, V-block and angle plate, toolmaker's clamp, optical comparator; and
18. correctly lay out a sheet metal pattern.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

cubit
span
palm
foot
inch
pace
meridian mile
stadia
yard
rod
meter
design
pattern development
product plan
bill of materials
measurement
linear measurement
fractions
decimals
conversion tables

KEY WORDS: DRAFTING

The words listed below pertain to drafting, but should be familiar to those students studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

symbols
dimensions
pictorial
visible line
hidden line
dimension line
circle
diameter
radius
arc
chord
semicircle
tangent line
area
computer-assisted drafting
blueprint
working drawing

KEY WORDS: TOOLS

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

surface plate
scriber
dividers
steel rule
hook rule
steel tape
circumference rule
metal square
solid steel square
combination set
bevel protractor
spirit level
swinging bevel
outside micrometer
inside micrometer
depth micrometer
screw thread micrometer
outside caliper
inside caliper
hermaphrodite caliper
sliding caliper
USS Gauge
Brown & Sharpe Gauge
American Wire Gauge
screw pitch gauge
surface gage
vernier height gage
machinist's hammer
prick punch
center punch
V-block
angle plate
toolmaker's clamp
optical comparator

TEACHING AIDS

- Overhead projector
- Test Key: 1-A, 2-C, 3-A, 4-C, 5-A, 6-D, 7-B, 8-A, 9-D, 10-B, 11-A, 12-C, 13-A, 14-B, 15-D, 16-A, 17-D, 18-D, 19-C, 20-A, 21-D, 22-A, 23-C, 24-A, 25-D, 26-C, 27-A, 28-C, 29-B, 30-D, 31-C, 32-D, 33-A, 34-A, 35-C

- Transparencies: You will find transparencies MW5-1 through MW5-25 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

  MW5-1: Designs for a Small Dish or Tray
  MW5-2: Drawing for a Crumb Tray Made from Sheet Metal
  MW5-3: Sheet Metal Ductwork Symbols
  MW5-4: Parts of a Circle

MW5-5: Parallel Line Development
MW5-6: Radial Line Development
MW5-7: The Metric World
MW5-8: The Metric System: An Easy Way to Remember
MW5-9: Think Metric
MW5-10: Popular Sayings the Metric Way
MW5-11: How to Measure with the Steel Rule
MW5-12: How to Use the Square Head of the Combination Set
MW5-13: How to Use the Center Head of the Combination Set
MW5-14: How to Use the Protractor Head of the Combination Set
MW5-15: Outside Micrometer: Name the Parts
MW5-16: What Are the Readings?
MW5-17: How to Correctly Hold an Outside Micrometer
MW5-18: How to Use the Outside Micrometer
MW5-19: How to Use the Outside Caliper
MW5-20: How to Use the Inside Caliper
MW5-21: How to Use the Hermaphrodite Caliper
MW5-22: How to Use the Slide Caliper
MW5-23: United States Standard Gauge
MW5-24: How to Use the Surface Gage
MW5-25: Layout

- Handouts: You will find Handouts No. 1 through No. 6 at the end of this unit. If you wish, these may be duplicated in quantity and given to students while they are studying different aspects of this unit.

Handout No. 1: Parallel Line Development
Handout No. 2: Radial Line Development
Handout No. 3: Product Plan Sheet
Handout No. 4: Linear Measurement
Handout No. 5: Problems
Handout No. 6: The Metric System

SUGGESTED REFERENCES

Budzik, R. S. Sheet Metal Technology. Indianapolis, Ind.: Bobbs-Merrill, 1981.

Feirer, J. L. SI Metric Handbook. New York: Charles Scribner's Sons, 1977.

Feirer, J. L., and Lindbeck, J. R. Basic Metalwork. Peoria, Ill.: Charles A. Bennett, 1978.

Graham, G. S. Metalworking: An Introduction. Belmont, Calif.: Breton Publishers, 1981.

Groneman, C. H., and Feirer, J. L. Getting Started in Metalworking. New York: McGraw-Hill, 1979.

Groneman, C. H., and Grannis, G. E. Exploring the Industries. Albany, N.Y.: Delmar, 1981.

Little, R., and Little, S. The Basic Book of Metalworking. Chicago: American Technical Society, 1979.

Ludwig, O. A.; McCarthy, W. J.; and Repp, V. E. Metalwork Technology and Practice. Bloomington, Ill.: McKnight, 1975.

Miller, R., and Morrisey, T. J., Metal Technology. Indianapolis, Ind.: Howard Sams, 1975.

Miller, W. R., et al. Metalworking. Bloomington, Ill.: McKnight, 1978.

Olivo, C. T. Fundamentals of Machine Technology. North Scituate, Mass.: Breton Publishers, 1981.

Zinngrabe, C. J. Sheet Metal Blueprint Reading for the Building Trades. Albany, N.Y.: Delmar, 1980.

Zinngrabe, C. J., and Schumacher, F. W. Practical Layout for the Sheet Metal Shop. Albany, N.Y.: Delmar, 1975.

SENTENCE OUTLINE

I. History
  A. In 4000 B.C., the earliest standard of linear measurement was recorded as the cubit—the length of the Pharaoh's forearm.
  B. In 2000 B.C., the Egyptians added (1) the span—the outstretched hand, (2) the palm, and (3) the mile—1,000 cubits.
  C. In 500 B.C., the Greeks used (1) the foot, (2) the inch, (3) the pace, (4) the meridian mile—1,000 paces, and (5) the stadia—1/10 of the meridian mile.
  D. In 1150, King Henry I established the yard—the length from the tip of his nose to the end of his thumb—and the inch—the length of three barley corns laid end to end.
  E. In 1550, the rod was established as the length of the left feet of the first 16 men out of church on a given Sunday.
  F. In 1558, Queen Elizabeth proclaimed the yard to be the length of a special bronze bar. It remained the standard for over 300 years.
  G. By 1795, France defined the meter as one ten-millionth of the distance from the north pole to the equator along a line near Paris.
  H. In 1851, Sir Joseph Whitworth invented the first machine capable of measuring one-millionth of an inch.
  I. In 1866, the meter became legal in the United States; however, it has never been mandated.

II. Design
  A. Designing is creative planning to meet some human need. (Transparencies MW5-1 and MW5-2)
  B. Any time you purchase one of several items, all of which you can afford and will serve your purpose, you are actually deciding which design you like best.
  C. Before any design can be done, a problem must exist which has to be solved.
  D. The design process must answer:
    1. What is the problem to be solved?
    2. What must the product do?
    3. What products presently in use can be adapted to the situation?
    4. What limitations exist (material/machinery)?
  E. The relationship of function is important to design.
    1. A functional product works well—it does the job it was intended to do.
    2. A product must not only work but also look good, and a product that looks good must also work well.
  F. The influence of material is important to design.
    1. The design of a metal product is complicated by the fact that different metals have different properties.
    2. Metal's properties also influence the type of product for which it can be used.

III. Drafting
  A. Once the design is selected from several possible sketches, the next step is to produce the required drawings.
    1. To work in industry, a person must understand a drawing—what different kinds of lines, signs, and abbreviations mean.
      a. All sheet metal ductwork is represented on drawings through the use of standardized symbols. (Transparency MW5-3)
      b. A standard for measurement symbols, understood by people in production, is also necessary because outside of home arts and crafts, products are produced by many people and in quantities.

2. A properly made drawing includes all dimensions that are needed to produce the part.
    a. The function of a product, or of an individual part of a product, will determine how precisely the part or product must be made.
    b. Drawings that do not require a great degree of accuracy use fractions; use decimals for greater accuracy.
3. Although only one view is occasionally needed, most industrial products require several views.
4. Pictorial sketches and pictorial drawings are only used to show the appearance of a product.
5. A person beginning in the world of technology should also know the different types of lines on working drawings.
    a. A visible line is a thick line which shows all edges of an object that can be seen.
    b. A hidden line is a thin line made of short (1/8") dashes. It is used to show edges that cannot be seen, just as if you could see through the solid object.
    c. A dimension line is a thin line, broken in the center to include a number and with arrowheads on the end, which shows the various sizes of a product.
6. It is important that the beginning student learn the different parts of a circle. (Transparency MW5-4)
    a. The circumference is the length of the curved line which forms the circle.
    b. The diameter is a straight line drawn through the center of the circle with both ends touching the circumference.
    c. The radius is one-half the diameter.
    d. An arc is any part of the circumference.
    e. A chord is a straight line connecting the low ends of an arc.
    f. A semicircle is half of a circle.
    g. A tangent line touches an arc or circumference at only one point.
    h. The area is the amount of surface inside the circumference.
7. The three forms of sheet metal pattern development are parallel-line, radial-line, and triangulation.
    a. All parallel-line developments require (1) an elevation view, (2) a plan view, and (3) a stretchout. They are used for products that have parallel sides (cylinders, rectangular objects). (Transparency MW5-5, Handout No. 1)
    b. Radial-line development is used to develop patterns for objects that do not have parallel sides, but are symmetrically tapered (cones, pyramids). (Transparency MW5-6, Handout No. 2)
    c. Triangulation is a pattern development used when the object has nonparallel sides and no common center.

B. An original drawing (master drawing) is usually produced with drafting instruments and/or a CAD (computer-assisted drafting) system.
    1. Reproductions of master drawings are usually referred to as blueprints, although only a small percentage are still produced by that process.
    2. The blueprint is the common medium through which the knowledge of the designer is transmitted to the production department.

IV. Product plan: Before beginning to make a product, it is necessary to have a product plan that contains (a) a working drawing, (b) a bill of materials, (c) a list of steps of procedure to make the product, in correct order, and (d) approval of your instructor. (Handout No. 3)

A. Working drawings of each part of a product should be attached to a product plan sheet.
    1. A working drawing contains (1) shapes of every part, (2) sizes of every part, (3) types of material, (4) types of finish, and (5) how many of each piece.
    2. The original working drawings are seldom used. Instead, blueprints of the original drawings are used.
    3. A working drawing contains all the information needed to make the product.
    4. Engineers and technologists use working drawings (orthographic multiview drawings) from which to work.

B. A bill of materials includes (1) the parts of the product, identified by numbers or letters, (2) number of pieces needed for each part, (3) size of material, (4) shape of material, (5) kind of material, (6) any standard parts included, and (7) unit cost and total cost per product.
    1. Metal wholesalers usually sell all metal by weight.
    2. School suppliers usually sell (a) bar stock by the foot, (b) sheet stock by the square foot, and (c) cast metals by the pound.

C. When a student learns to prepare a product plan sheet, he or she is actually doing work similar to that performed by manufacturing engineers and/or technologists.

V. Measurement is the universal language for the control of manufacturing.
  A. Before designing and planning a product, the student must understand how to measure and lay out metal. (Handout No. 4)
    1. The term that means measuring length dimensions is linear measurement.
    2. The ability to add and subtract common fractions is a valuable aid in making accurate measurements. (Handout No. 5)
    3. You must know how to convert common fractions to decimal equivalents, and how to convert decimals into fractional equivalents, in order to read and use precision measuring tools.
  B. There are three common systems of measurement: (1) English fraction, (2) English decimal, and (3) metric. (Handout No. 6)
    1. The metric system began in France before 1800.
    2. Most U.S. manufacturers who are engaged in international trade have already converted to the metric system. (Transparency MW5-7)
      a. The metric system is based upon the base ten and powers of ten. (Transparency MW5-8)
      b. A full range of metric scales and micrometers is available. (Transparencies MW5-9 and MW5-10)
      c. The most used metric rules are the 300-millimeter and 150-millimeter.
  C. The skill of any technologist is limited by the person's ability to accurately use the correct measuring instrument.

VI. Measuring tools and layout tools
  A. A surface plate is a large iron or granite plate with a very flat surface on which tools are used to lay out work.
    1. Be very careful when working on a surface plate.
    2. Do not nick it.
    3. Cover it when not in use.
    4. If it is made of iron, coat it with oil.
  B. The scriber is the metal industry's pencil.
    1. It is made of hardened steel with a sharp point.
    2. The scratch awl is similar to the scriber except that it has a wooden or plastic handle.
  C. Dividers are used to lay out arcs and circles, and to measure equal distances.

D. Steel rules can be used for (1) measuring dimensions, (2) laying out, and (3) a straightedge. (Transparency MW5-11)

   1. In measuring, it is necessary to understand the divisions of the steel rule and their values.
   2. Steel rules usually have four separate scales, the smallest graduation on each respective scale being 1/8", 1/16", 1/32", and 1/64".

E. A hook rule has an arm attached to one end to make it easier to make accurate measurements.

F. A steel tape is used to make long measurements and to measure bent or curved surfaces.

G. A circumference rule is 3 feet long and has a special scale directly below the 3-foot scale that shows the circumference needed for any given diameter.

H. Squares

   1. The common metal square is used to lay out parallel and perpendicular lines, and to square the end of a piece of metal.
   2. The solid steel square is made in one piece of hardened steel and is used for more exact work than a square head of a combination set.

I. The combination set—sometimes referred to as a combination square—is the most commonly used set of tools in the layout laboratory and includes (1) square head, (2) the center head, (3) the bevel protractor, (4) spirit level, (5) steel rule, and (6) scriber.

   1. The square head of the combination set can be used to measure 45^{0} angles, 90^{0} angles, and depths. (Transparency MW5-12)
   2. The center head of a combination set may be used to extend a line around a corner and—with the steel rule—to find the center of a round piece. (Transparency MW5-13)
   3. The bevel protractor of the combination set is used—along with the steel rule—to measure any angle. (Transparency MW5-14)
   4. A spirit level is usually located in both the square head and the level protractor of the combination set and is used to level work.

J. The swinging bevel can be clamped at any angle for laying out, or measuring any angle.

K. A micrometer (mike, for short) is an instrument that measures in thousandths of an inch. (Transparencies MW5-15 and MW5-16)

   1. The outside micrometer is used to measure outside diameters and thicknesses of flat pieces. (Transparencies MW5-17, MW5-18, and MW5-19)
   2. The inside micrometer is used to measure the diameter of holes. (Transparency MW5-20)
   3. The depth micrometer is used to measure the depth of slots, holes, and grooves.
   4. The screw thread micrometer is used to measure the pitch diameter of screw threads.

L. Calipers

   1. An outside caliper is a two-legged steel instrument with the legs bent inward. It is used to measure outside diameters, widths, and thicknesses.
   2. An inside caliper is a two-legged steel instrument with the legs bent outward. It is used to measure spaces and to measure diameters of holes.
   3. The hermaphrodite caliper has one pointed leg and one leg bent inward. It is used to scribe lines parallel to an edge and to find the center of the end of a round bar. (Transparency MW5-21)
   4. The sliding caliper combines the features of the inside and outside calipers and a rule into one, direct-reading instrument which can be locked in any position. (Transparency MW5-22)

M. Gauges
   1. The United States Standard (USS) Gauge is used to measure the thickness of galvanized sheet. (Transparency MW5-23)
   2. The Brown and Sharpe or American Wire Gauge Standard is used to measure the thickness of nonferrous metal sheet.
   3. Thickness gauges are available in both the English and metric systems, and are used to check small distances.
   4. The screw pitch gauge is used to determine the pitch of a screw thread.

N. The surface gage is a scriber on a flat base that can be set at any angle. It is used to scribe lines parallel to a surface. (Transparency MW5-24)

O. The vernier height gage is more accurate than a surface gage and is also used to scribe lines parallel to a surface.

P. A machinist's hammer is sometimes called a ball-peen hammer. Use one that weighs 2 to 6 ounces (without the handle) for layout work.

Q. Punches
   1. The prick punch is used to—
      a. locate the centers for drawing arcs and circles;
      b. locate the centers for holes that will be punched or drilled; and
      c. locate bending lines.
   2. The center punch looks like the prick punch except that the point is not as sharp (usually 90°). It is used to mark the center of holes to be drilled.

R. The V-block is a block of steel with "V" grooves and a clamp. It is used to hold round stock during layout work.

S. An angle plate has two surfaces at right angles to each other. Work is sometimes clamped to an angle plate during layout.

T. The toolmaker's clamp—often called a parallel clamp—is used to hold parts together, or to hold work onto the angle plate, during layout.

U. The optical comparator is used to inspect very close tolerances by projecting the part image onto a screen against the drawing of the part.

VII. Laying out is the marking of lines, circles, and arcs on metal surfaces.

A. Procedure for sheet metal layout: (Transparency MW5-25)
   1. Cut and square the metal to the precise cut size.
   2. Work from the bottom and left-hand edge of the metal.
   3. Lay out all the horizontal lines.
   4. Lay out all the vertical lines.
   5. Check all the measurements.

B. If the lines do not show up clearly, it may be necessary to paint the metal with bluing fluid before scribing.

C. In making a pattern, you must allow extra metal for hems and seams.
   1. Hems are folded edges that make a product more rigid, more attractive, and safer.
   2. Seams are used for joining metal.

D. To make a complete sheet metal layout, the pattern must show where the metal will be cut out to ease the fitting of the pieces together—called notches.

E. Methods of transfer
   1. To transfer a paper pattern to sheet metal, use a scratch awl, or hammer and prick punch to mark each line intersection. Remove the paper pattern, and connect the points with a straightedge.
   2. A template is a transfer pattern that is used for laying out duplicate pieces, and is usually made from plastic or sheet metal.

F. Conversion tables are available, but should not be used unless absolutely necessary. To incorporate metrics, begin by laying out the product using metric measuring instruments.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pens, pencils
- Calculators
- Multiview drawings
- Basic drafting equipment
- Metal work laboratory price sheet
- Various English and metric rules
- Cardboard, plastic tubing, tape, glue, scissors
- Graph paper
- Various measuring and layout tools

SUGGESTED STUDENT ACTIVITIES

1. Prepare drawings of the parts of the body that early humans used for various measurements.
2. Discuss the design principles of form, function, balance, etc.
3. Discuss sources for product ideas.
4. Make several design sketches for possible use.
5. Locate a product such as a toy or tool, bring it to class, and redesign the product.
6. Discuss why working drawings are the language of the industrial world.
7. Obtain examples of different kinds of drawings. Distribute and discuss them with the class.
8. Obtain examples of industrial drawings and drawings produced on a CAD system. Display on the bulletin board.
9. Describe the relationship between producing interchangeable parts and dimensional measurements.
10. Show films of automated systems for layouts used in industry.
11. Using calculators, have students convert several fractions into decimals, and decimals into specified fractions (64ths, 32nds, 16ths, and 8ths).
12. Have students read multiview drawings.
13. Have students do a simple drawing.
14. Demonstrate the development of sheet metal patterns.
15. Have each student select three or four products made from sheet metal, and then determine what type of pattern development was used in making the template.
16. Prepare a display that shows an industrial product from drawing, through various stages of production, to the finished product.
17. As a class, complete a product plan sheet for a product to be produced by intermittent manufacturing.
18. Discuss how different metals are priced (per foot, per square foot, per pound, etc.).
19. Assist students in computing the cost of a product.
20. Have students estimate the cost of a product, then compare this with the actual cost after completion.
21. Research the present status of federal legislation regarding converting the United States to the metric system of measurement.
22. Have students measure pieces of metal stock using the English and metric systems.
23. Using different sizes of cardboard and plastic tubing, construct a working model of a micrometer.
24. Make a list of companies that make measurement and/or layout tools.
25. Demonstrate the use of layout tools such as squares, measuring tools, marking tools, radium tools, etc.
26. Discuss gage number system and sizing of sheet metal.

27. Compare the similarity of drafting equipment and layout equipment in the metal lab.
28. Discuss methods of saving metal in layout and use.
29. Using graph paper, have students explore several ways to lay out material; determine the most efficient method.
30. Discuss methods of marking metal.
31. Scatter the various standard measuring and layout tools throughout the lab. Place each tool on a 3 x 5 card with a number of it. Each student, using a numbered sheet, must identify each tool.
32. This curriculum guide includes the study of ornamental metal work, forging (including heat treatment), and casting, incorporating the use of various hand tools and machine tools. If you wish, you may want to have the students—individually or in small groups—do custom production of some small item. However, since the major thrust of industry is intermittent production, you should seriously consider the following:
    a. Design and prepare working drawings of three or more large items, each of which includes the various units listed above (ornamental metal work, sheet metal work, etc.).
    b. At the conclusion of each unit, review those parts of the item relevant to that particular unit.
    c. At the conclusion of all units in this guide, divide the class into teams and assign each team a certain part(s) of the product.
    d. The student teams are to produce a sufficient quantity so each student will have a completed product (allow for errors).
    e. Maintain inventory control.
    f. After all parts are completed, set up an assembly line and put the product together.

    Using this type of teaching, your students will receive a more realistic concept of industry, and much larger and more interesting products can be produced.

Vocabulary Worksheet

1. cubit
2. span
3. palm
4. foot
5. inch
6. pace
7. meridian mile
8. stadia
9. yard
10. rod
11. meter
12. design
13. pattern development
14. product plan
15. bill of materials
16. measurement
17. linear measurement
18. fractions
19. decimals
20. conversion tables

Drafting Vocabulary Worksheet

1. symbols
2. dimensions
3. pictorial
4. visible line
5. hidden line
6. dimension line
7. circle
8. diameter
9. radius
10. arc
11. chord
12. semicircle
13. tangent line
14. area
15. computer-assisted drafting
16. blueprint
17. working drawing

Tools Vocabulary Worksheet

1. surface plate
2. scriber
3. dividers
4. steel rule
5. hook rule
6. steel tape
7. circumference rule
8. metal square
9. solid steel square
10. combination set
11. bevel protractor
12. spirit level
13. swinging bevel
14. outside micrometer
15. inside micrometer
16. depth micrometer
17. screw thread micrometer
18. outside caliper
19. inside caliper
20. hermaphrodite caliper
21. sliding caliper
22. USS Gauge
23. Brown & Sharpe Gauge
24. American Wire Gauge
25. screw pitch gauge
26. surface gage

27. vernier height gage

28. machinist's hammer

29. prick punch

30. center punch

31. V-block

32. angle plate

33. toolmaker's clamp

34. optical comparator

TEST

UNIT 5: MATERIAL LAYOUT

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: D 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. The earliest standard of recorded linear measurement was the--
A. cubit
B. span
C. palm
D. mile

___ 2. The yard as the length from the tip of his/her nose to the end of his/her thumb was established by--
A. Queen Elizabeth
B. Queen Mary
C. King Henry I
D. Sir Joseph Whitworth

___ 3. The first machine capable of measuring one-millionth of an inch was invented by--
A. Sir Joseph Whitworth
B. Eli Whitney
C. King Henry I
D. Sir Henry Bessemer

___ 4. The main ingredient that determines how precisely a product must be made is--
A. the design
B. the material
C. the function of the product
D. none of the above

___ 5. Although an industrial product usually has several views of the product in order to produce it, the number of views **required** for an industrial product is/are--
A. one
B. two
C. three
D. six

___ 6. A thick line which shows all edges of an object that can be seen is--
A. dimension line
B. hidden line
C. center line
D. visible line

___ 7. A thin line made of short dashes, and used to show edges that cannot be seen, just as if you could see through the solid object is a --
A. dimension line
B. hidden line
C. center line
D. visible line

___ 8. A thin line, broken in the center to include a number, and with arrowheads on the ends, which shows the various sizes of a product, is a--
A. dimension line
B. hidden line
C. center line
D. visible line

___ 9. The length of the curved line which forms the circle is the--
A. chord
B. tangent line
C. area
D. circumference

___ 10. A straight line drawn through the center of the circle with both ends touching the circumference is the--
A. radius
B. diameter
C. chord
D. tangent line

___ 11. Any part of the circumference is a/an--
A. arc
B. chord
C. radius
D. tangent line

___ 12. A sheet metal pattern development that is used for products such as cylinders and rectangular-shaped objects is--
A. radial-line development
B. triangulation
C. parallel-line development
D. simple-line development

___ 13. A drawing that contains shapes of every part, sizes of every part, types of material, types of finish, and how many of each piece is--
A. working drawing
B. orthographic, multiview drawing
C. sheet metal pattern development
D. pictorial drawing

___ 14. Metal wholesalers usually sell metal by the--
A. linear foot
B. weight
C. board foot
D. square foot

___ 15. The universal language for the control of manufacturing is--
A. metric
B. symbols
C. drawing
D. measurement

___ 16. A type of measurement used for measuring length dimensions is--
A. linear measurement
B. dimensional measurement
C. longitudinal measurement
D. depth measurement

___ 17. A common system of measurement is--
A. English fraction
B. English decimal
C. metric
D. all of the above

___ 18. A flat surface upon which tools are used to lay out work is the--
A. surface gage
B. solid steel square
C. conversion table
D. surface plate

___ 19. The metal industry's pencil is the--
A. divider
B. caliper
C. scriber
D. bevel

___ 20. An instrument used to lay out arcs and circles is the--
A. divider
B. caliper
C. scriber
D. bevel

___ 21. The smallest graduation on a steel rule is--
A. 1/8"
B. 1/16"
C. 1/32"
D. 1/64"

___ 22. The part of a combination set normally used to measure a 90° angle is the--
A. square head
B. center head
C. bevel protractor
D. steel rule

___ 23. The part of a combination set normally used to measure a 30° angle is the--
A. square head
B. center head
C. bevel protractor
D. steel rule

___ 24. The part of a combination set normally used to measure a 45° angle is the--
A. square head
B. center head
C. bevel protractor
D. steel rule

___ 25. In addition to the square head, center head, and bevel protractor, this is also part of the combination set:
A. spirit level
B. steel rule
C. scriber
D. all of the above

___ 26. The micrometer used to measure the thickness of flat pieces is the--
A. inside micrometer
B. screw thread micrometer
C. outside micrometer
D. depth micrometer

___ 27. The micrometer used to measure the diameter of holes is the--
A. inside micrometer
B. screw thread micrometer
C. outside micrometer
D. depth micrometer

___ 28. The caliper used to scribe lines parallel to an edge is the--
A. outside caliper
B. inside caliper
C. hermaphrodite caliper
D. sliding caliper

___ 29. The thickness of galvanized sheet is measured with the--
A. thickness gauge
B. United States Standard Gauge
C. screw pitch gauge
D. Brown and Sharpe Gauge

___ 30. The thickness of nonferrous sheet is measured with the--
A. thickness gauge
B. United States Standard Gauge
C. screw pitch gauge
D. Brown and Sharpe Gauge

___ 31. The most accurate tool for scribing lines parallel to a surface is the--
A. hermaphrodite caliper
B. surface gage
C. vernier height gage
D. Brown and Sharpe Gauge

___ 32. A tool used to mark the center of holes prior to drilling is the--
A. scriber
B. vernier height gage
C. prick punch
D. center punch

___ 33. Round stock is held during layout with a--
A. V-block
B. angle plate
C. toolmaker's clamp
D. parallel clamp

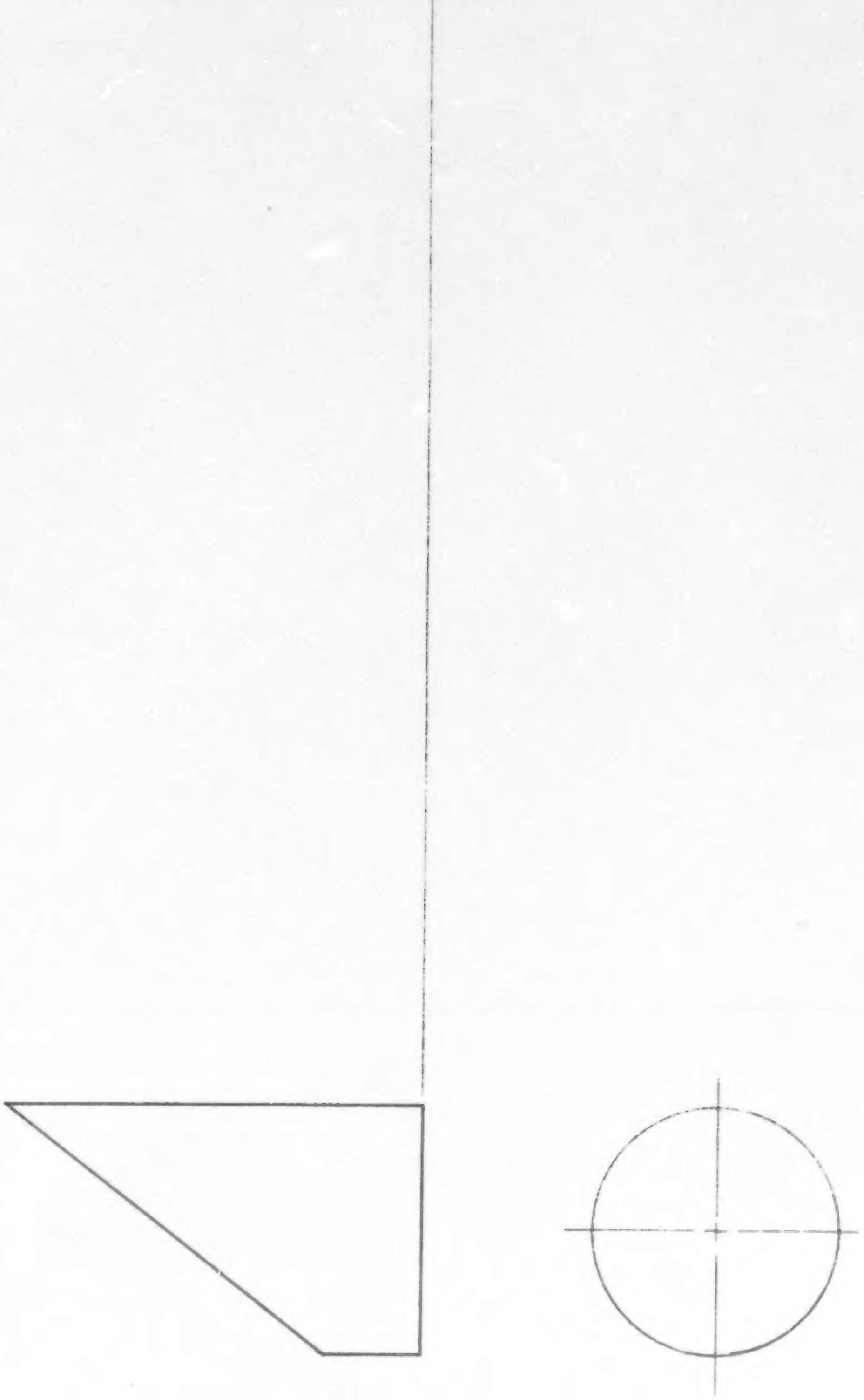
___ 34. Folded edges that make a product safer are--
A. hems
B. notches
C. seams
D. folds

#

___ 35. This is used for joining metal:
A. hems
B. notches
C. seams
D. folds

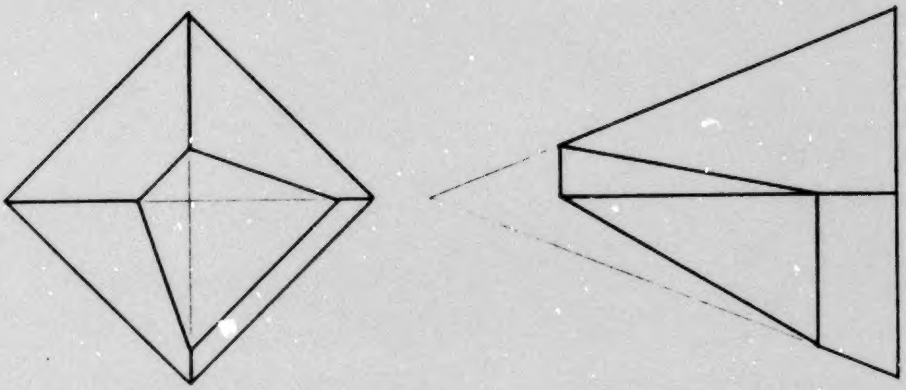
HANDOUT NO. 1

PARALLEL LINE DEVELOPMENT



HANDOUT NO. 2

RADIAL LINE DEVELOPMENT



HANDOUT NO. 3

PRODUCT PLAN SHEET
(Attach Working Drawing)

Name______________________________ Grade________

Product______________________________ Hour________

Source of product idea, if other than your own design______________________

____

Estimated Time__________ Actual Time____________ Approved____________

BILL OF MATERIALS

Part No.	No. of Pieces	Size			Material	Unit Cost (per sq. ft., lb., etc.)	Total Cost
		T	W	L			
						Total Cost	

Manufacturing Procedure
(See "Flow Process Chart" from Unit I: M1-11)

HANDOUT NO. 4

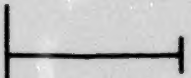
LINEAR MEASUREMENT

Section I How many:

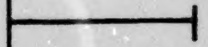
1/16ths in 1/8"__________
1/8ths in 1/4"__________
1/4ths in 1"__________
1/4ths in 1/2"__________
1/32nds in 3/8"__________
1/32nds in 5/16"__________
1/16ths in 7/8"__________
1/8ths in 1"__________
1/64ths in 5/8"__________
1/64ths in 3/4"__________

1/32nds in 1 ½"__________
1/16ths in 1½"__________
1/64ths in 2"__________
1/64ths in 5 1/32"__________
1/64ths in 3 1/16"__________
1/16ths in 1 3/4"__________
1/32nds in 11 9/16"__________
1/8ths in 4 3/4"__________
1/16ths in 7 13/16"__________
1/4ths in 10"__________

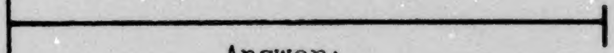
Measure each of the following lines to the nearest 1/16 of an inch:



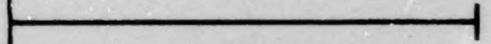
Answer:______________



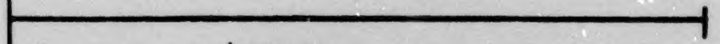
Answer:______________



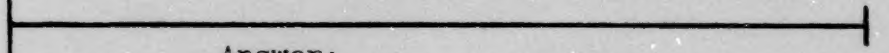
Answer:______________



Answer:______________



Answer:______________



Answer:______________

HANDOUT NO. 5

PROBLEMS

Solve the following problems:

1. 1/8 - 1/16 = ________

2. 1/4 - 1/16 = ________

3. 1/4 + 1/8 = ________

4. 1/2 + 1/8 = ________

5. 3/4 - 1/16 = ________

6. 1 - 1/16 = ________

7. 3/4 + 1/8 = ________

8. 3/4 - 1/8 = ________

9. 3/8 - 1/16 = ________

10. 1 - 1/4 = ________

11. 1/2 - 1/16 = ________

12. 1/2 - 1/4 = ________

13. 7/8 + 1/16 = ________

14. 1/4 + 1/16 = ________

15. 1/4 - 1/8 = ________

16. 1/2 + 1/2 = ________

17. 1/2 x 3/8 = ________

18. 1/2 x 3/4 = ________

19. 2 x 5/8 = ________

20. 2 x 3/8 = ________

21. 2 x 1/8 = ________

22. 2 x 1/4 = ________

23. 2 x 13/16 = ________

24. 2 x 7/16 = ________

25. 2 x 9/16 = ________

HANDOUT NO. 6

THE METRIC SYSTEM

With the flexible metric tape provided, measure the following parts of your body.

1. foot length __________cm
2. distance around your waist __________cm
3. distance around your wrist __________cm
4. length of your shortest finger __________cm
5. span of your hand (little finger to thumb) __________cm
6. distance around your head __________cm

Measure these distances with a metric rule.

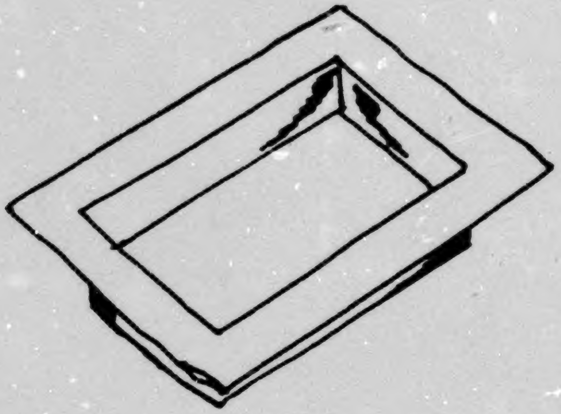
1. floor to top of your desk __________mm
2. floor to the seat of your chair __________mm
3. length of your pencil __________mm
4. width of the door to the laboratory __________mm
5. floor to top of chalkboard __________mm

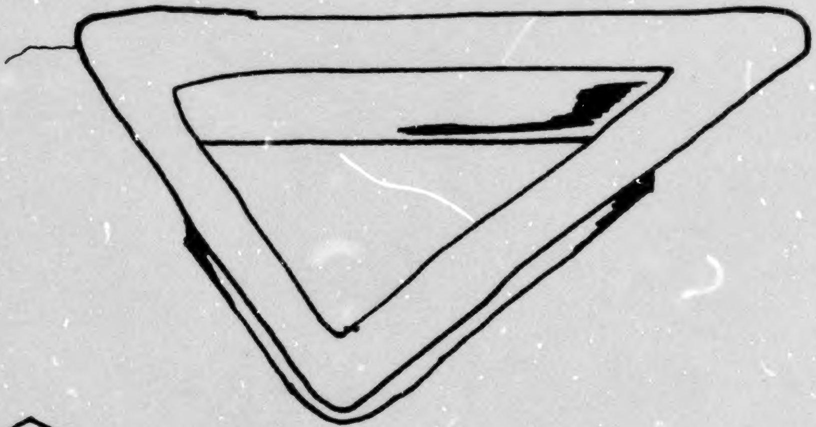
Measure these diameters with the metric calipers

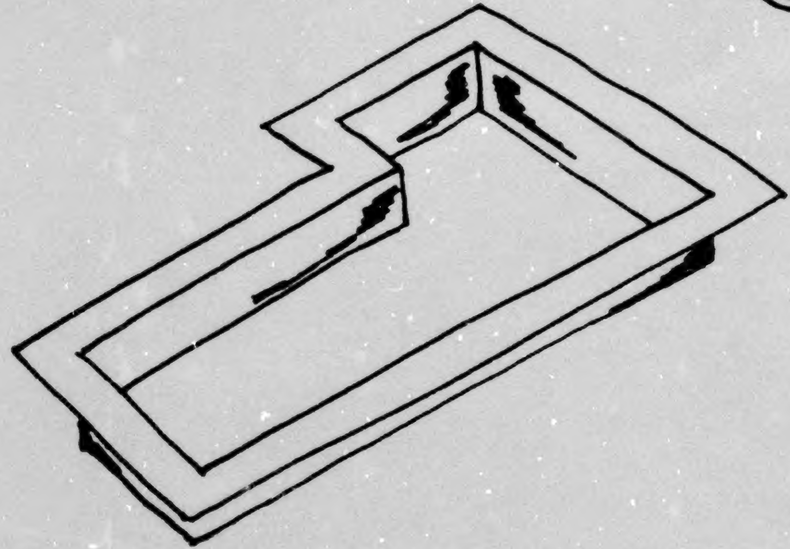
1. diameter of a pencil or pen __________mm
2. diameter of a dime __________mm
3. diameter of a quarter __________mm
4. thickness of a quarter __________mm

DESIGNS FOR A SMALL DISH OR TRAY

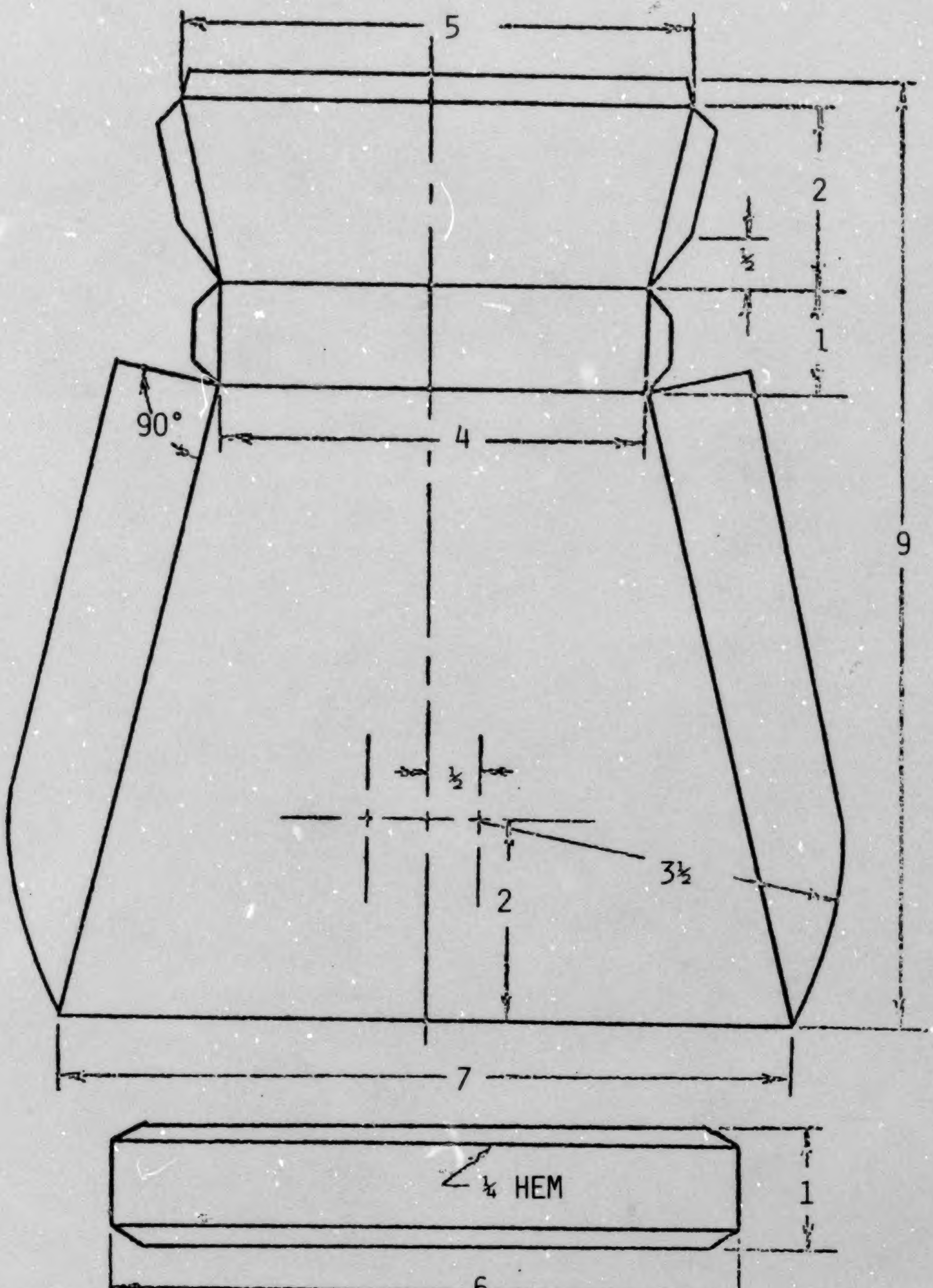
MW5-1



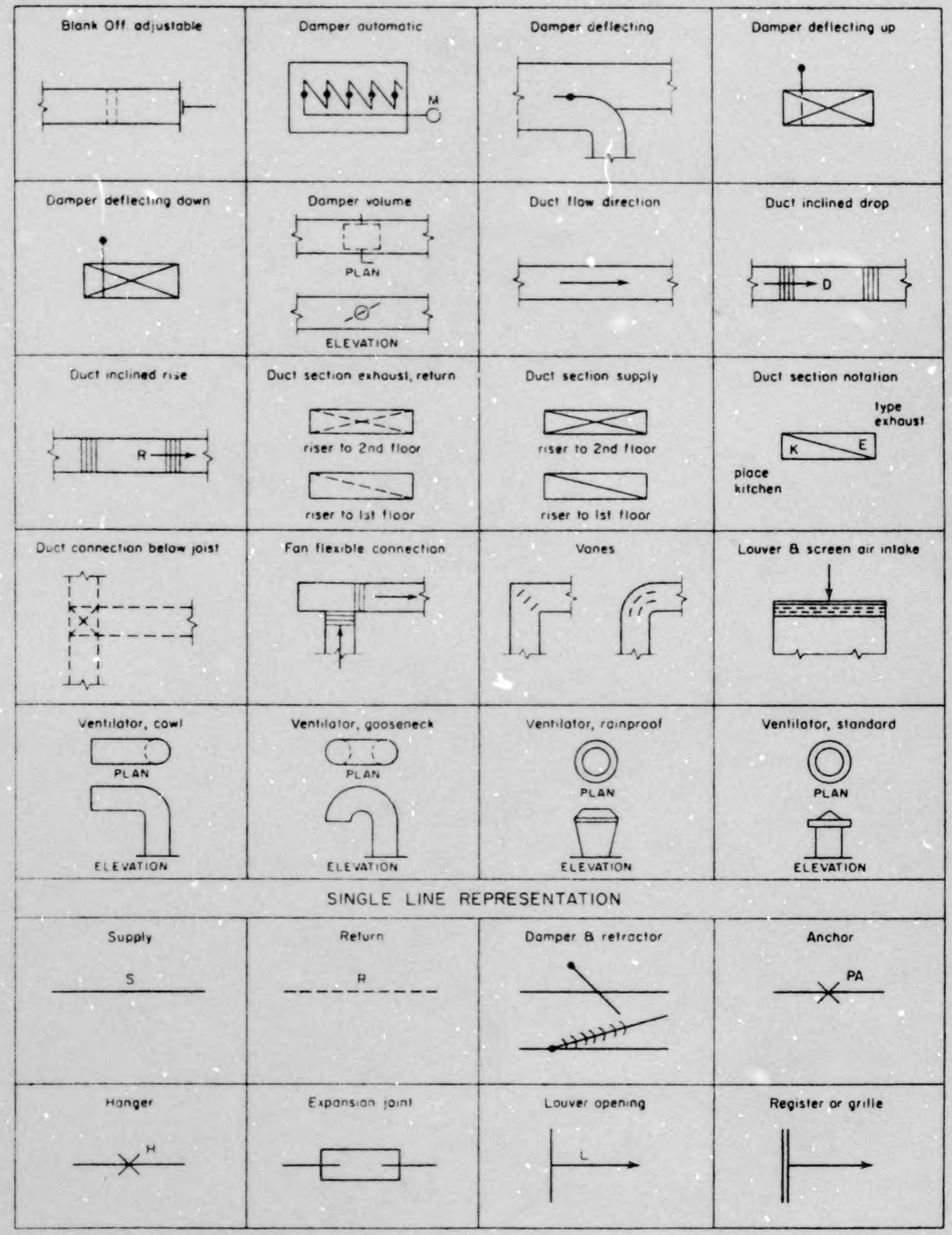




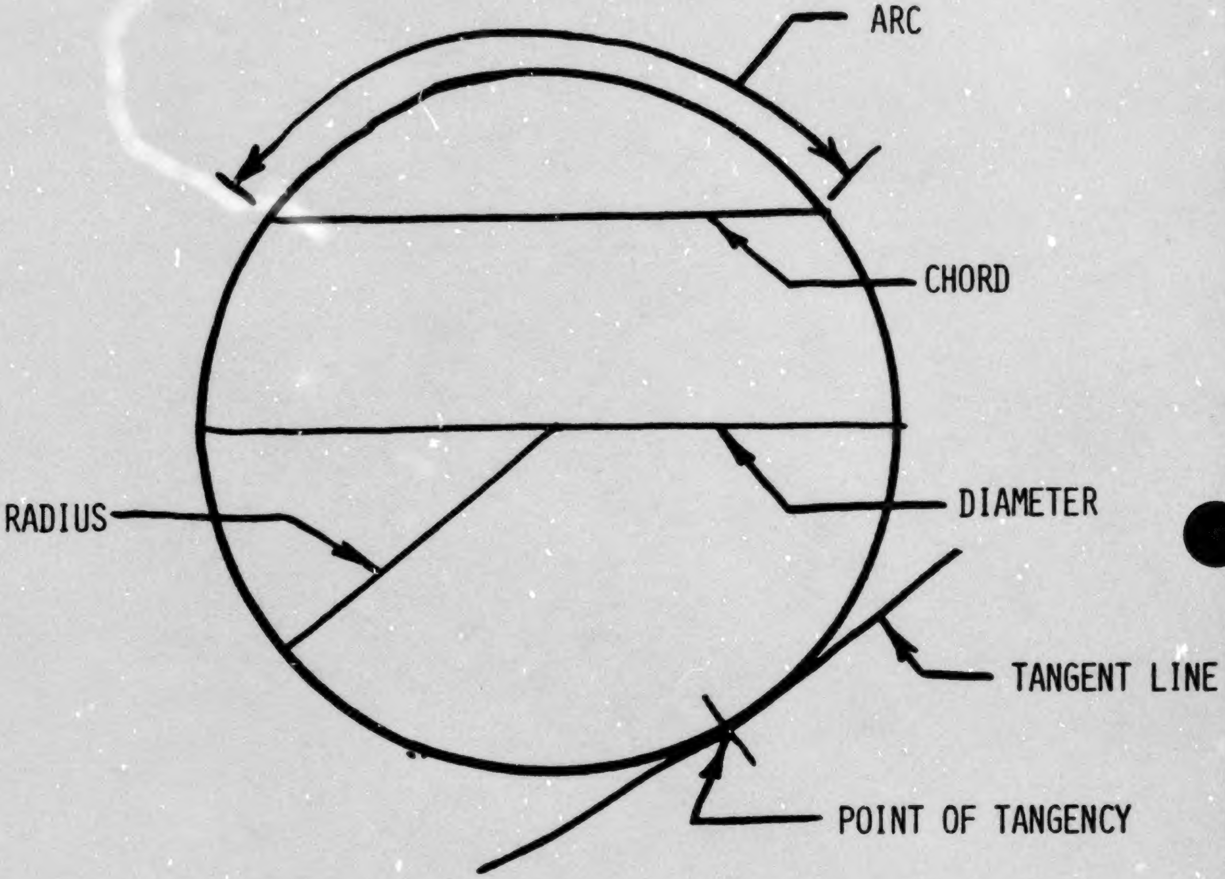
DRAWING FOR A CRUMB TRAY MADE FROM SHEET METAL


5
2
½
1
90°
4
9
½
3½
2
7
¼ HEM
1
6

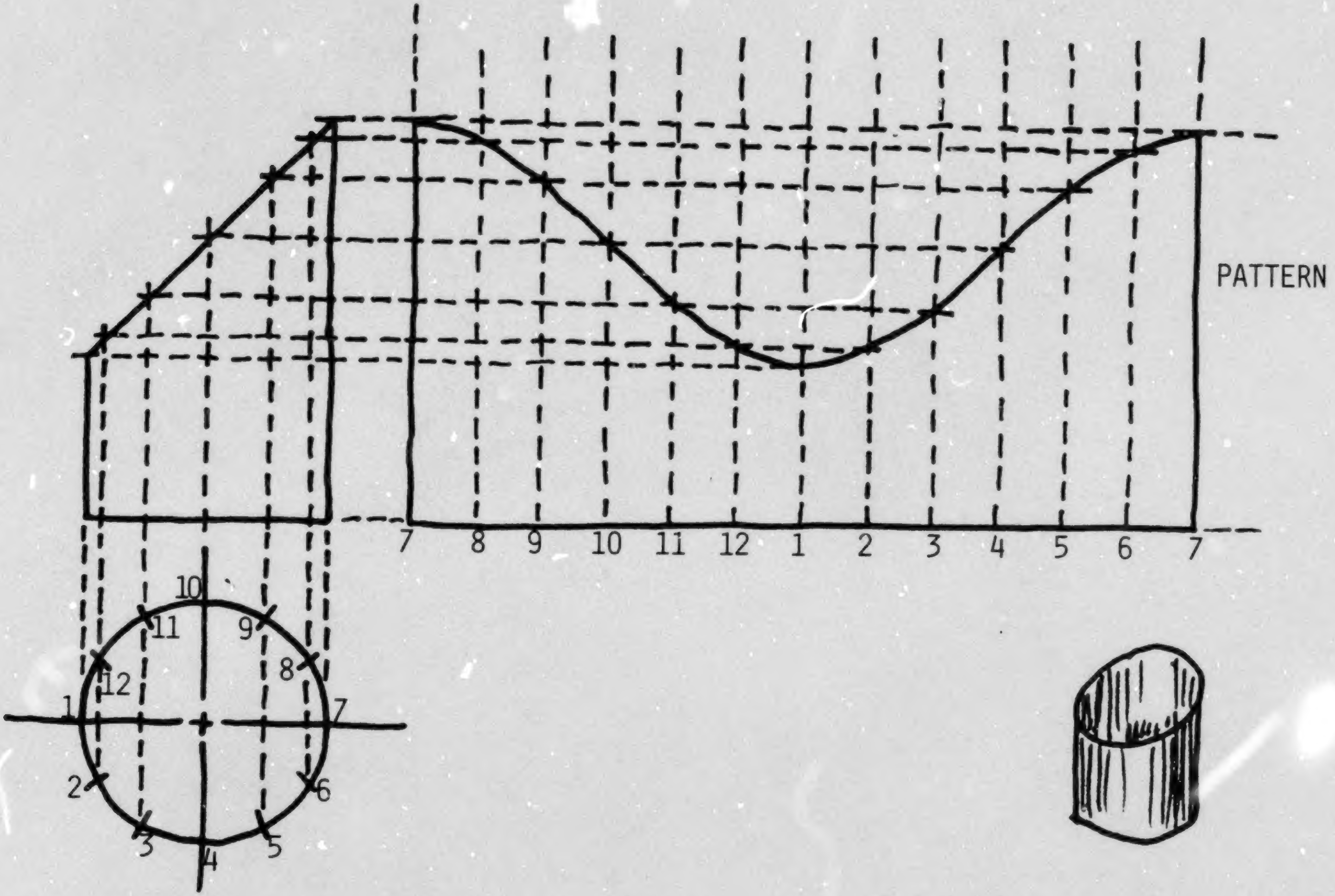
SHEET METAL DUCTWORK SYMBOLS


Blank Off adjustable
Damper automatic
M
Damper deflecting
Damper deflecting up
Damper deflecting down
Damper volume
PLAN
ELEVATION
Duct flow direction
Duct inclined drop
D
Duct inclined rise
R
Duct section exhaust, return
riser to 2nd floor
riser to 1st floor
Duct section supply
riser to 2nd floor
riser to 1st floor
Duct section notation
type
exhaust
K
E
place
kitchen
Duct connection below joist
Fan flexible connection
Vanes
Louver & screen air intake
Ventilator, cowl
PLAN
ELEVATION
Ventilator, gooseneck
PLAN
ELEVATION
Ventilator, rainproof
PLAN
ELEVATION
Ventilator, standard
PLAN
ELEVATION
SINGLE LINE REPRESENTATION
Supply
S
Return
R
Damper & retractor
Anchor
PA
Hanger
H
Expansion joint
Louver opening
L
Register or grille

PARTS OF A CIRCLE


ARC
CHORD
DIAMETER
RADIUS
TANGENT LINE
POINT OF TANGENCY

PARALLEL LINE DEVELOPMENT


PATTERN
7
8
9
10
11
12
1
2
3
4
5
6
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11
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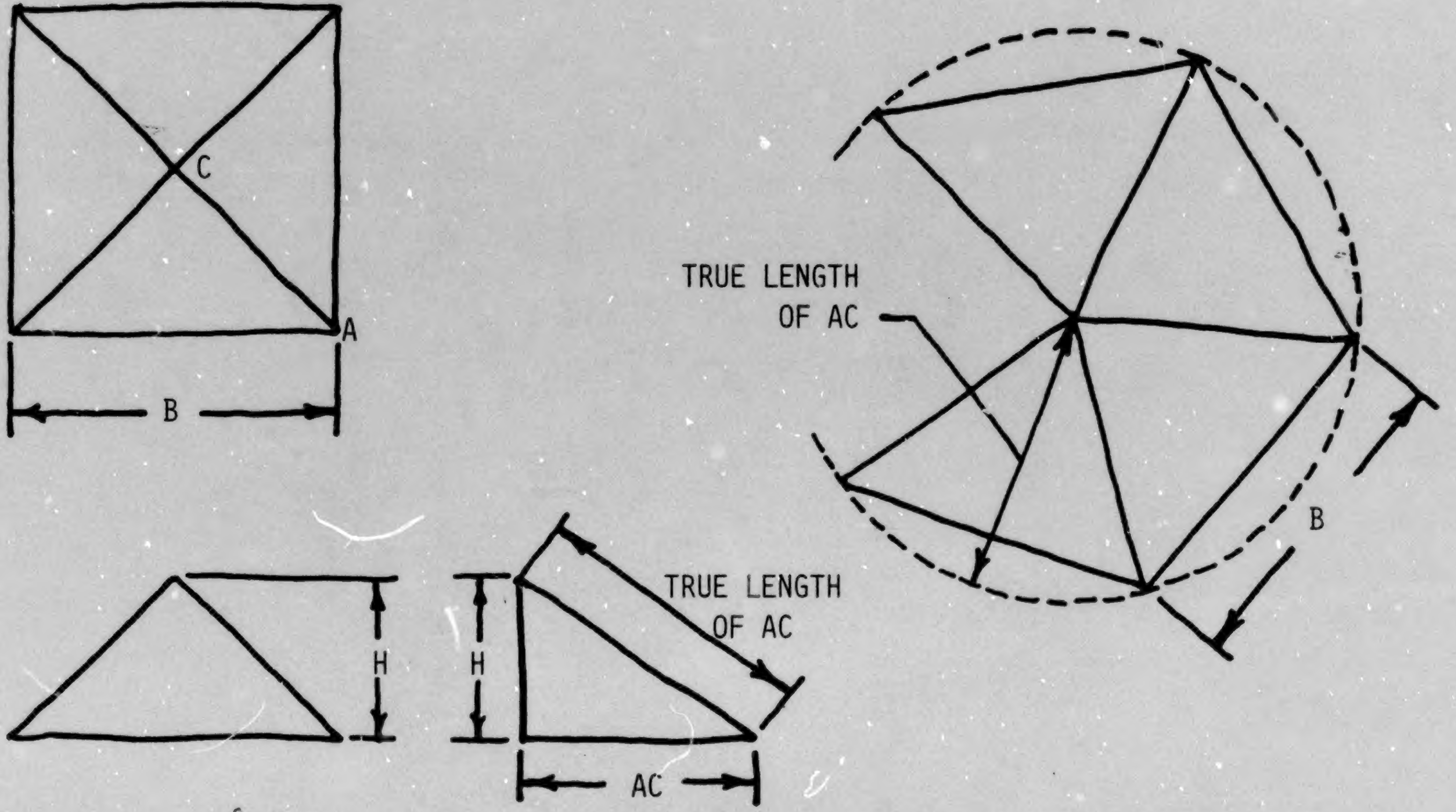
4
5

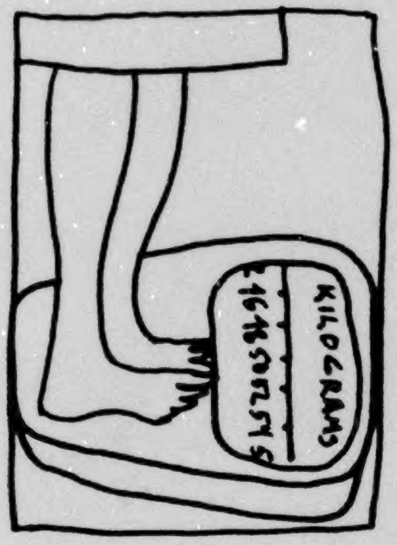
RADIAL LINE DEVELOPMENT

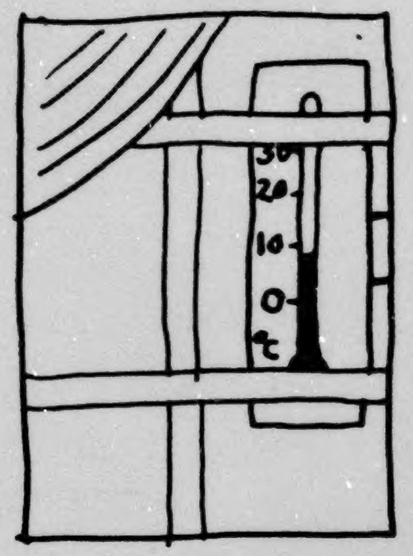
MW5-6

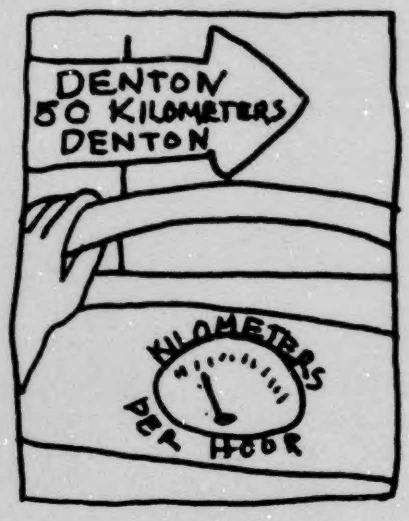

C
A
B
H
H
AC
TRUE LENGTH OF AC
TRUE LENGTH OF AC
B

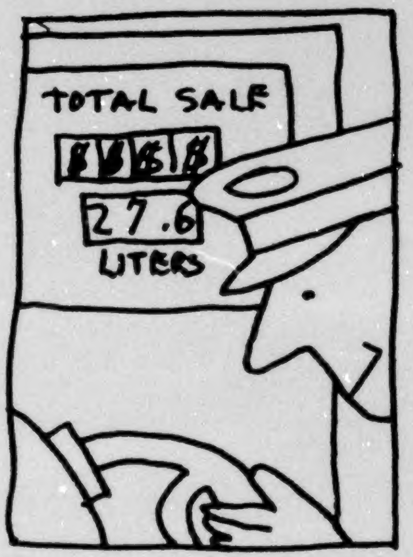
201

MW5-7



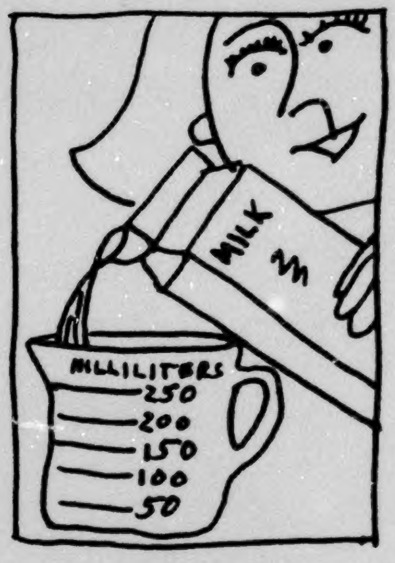



DENTON
50 KILOMETERS
DENTON
KILOMETERS PER HOUR


TOTAL SALE
27.6
LITERS

THE

METRIC WORLD


MILK
M
MILLILITERS
250
200
150
100
50

THE METRIC SYSTEM
AN EASY WAY TO REMEMBER

MONEY		METRIC
DOLLAR	1/10	METRE
DIME	1/10	DECIMETRE
CENT	1/10	CENTIMETRE
MILL	1/10	MILLIMETRE

THINK METRIC

MW5-9

RHODE ISLAND
IS
2717 SQUARE
KILOMETRES

TEXAS
IS
678,927 SQUARE KILOMETRES

POPULAR SAYINGS
THE METRIC WAY

453.60 GRAMS OF FLESH

A 30.48 CENTIMETERS LONG HOT DOG

IT HIT ME LIKE 907 KILOGRAMS OF BRICKS

PETER PIPER PICKED 8.809 LITERS OF PICKLED PEPPERS

GIVE HIM 2.54 CENTIMETERS AND HE'LL TAKE 1609 METERS

28.349 GRAMS OF PREVENTION ARE WORTH 453.60 GRAMS OF CURE

HOW TO MEASURE WITH THE STEEL RULE

MW5-11

1. REMOVE BURRS FROM THE WORKPIECE
2. POSITION THE STEEL RULE WITH THE END AGAINST THE REFERENCE POINT
3. READ THE MEASUREMENT AT THE MEASURED POINT

HOW TO USE THE
SQUARE HEAD OF THE COMBINATIO

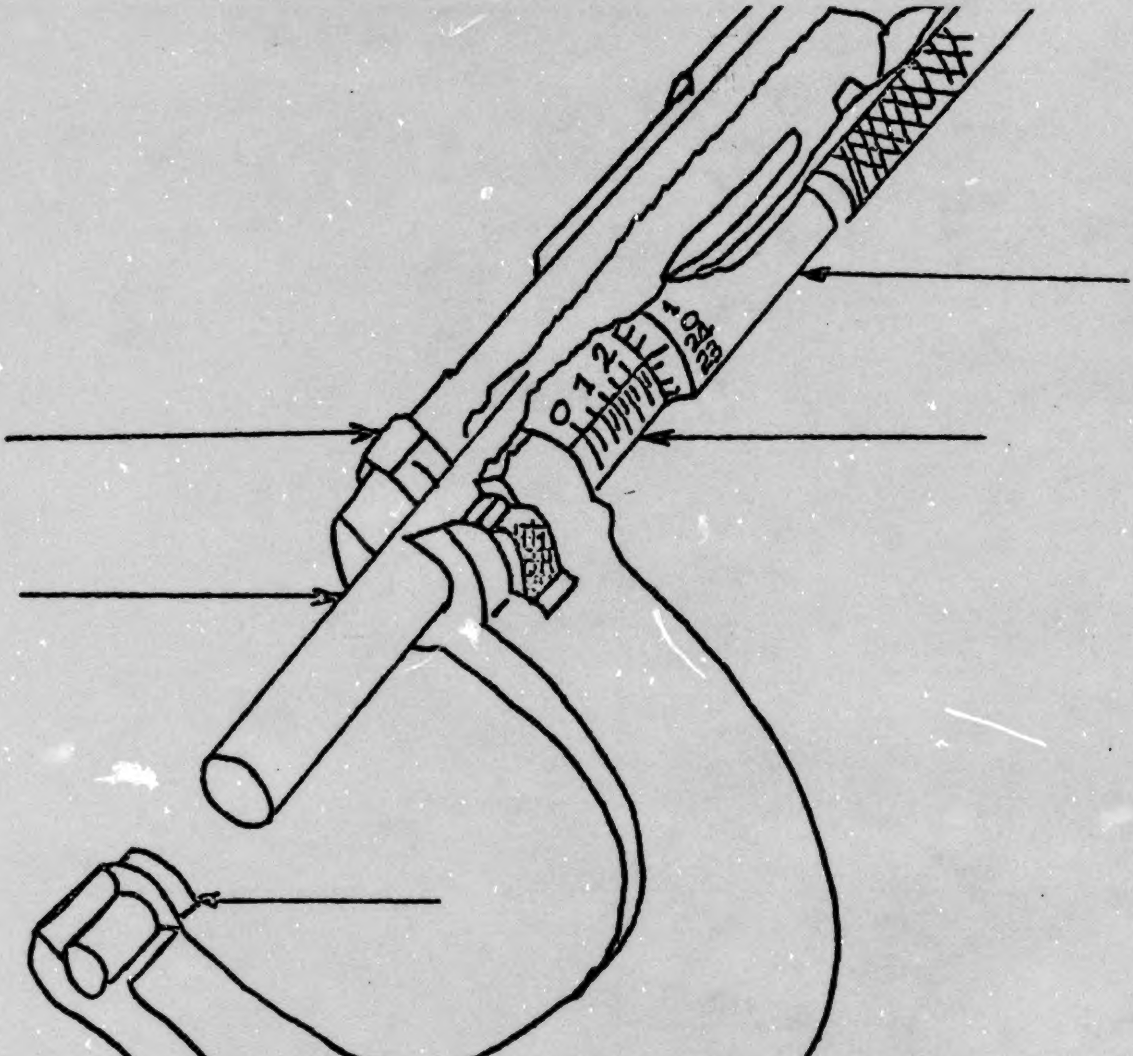
1. REMOVE BURRS FROM THE WORKPIE
2. TURN THE CLAMPING NUT SO THAT BLADE MAY BE MOVED
3. HOLD THE HEAD AGAINST THE REF SURFACE
4. MOVE THE BLADE UNTIL IT REACH DESIRED POINT
5. READ THE DIMENSION ON THE BLA

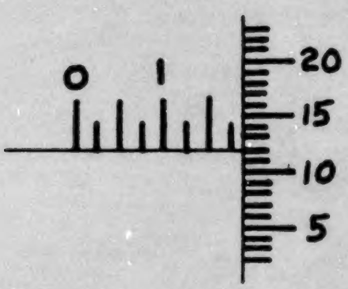
HOW TO USE THE
CENTER HEAD OF THE COMBINATIO

1. REMOVE BURRS FROM THE WORKPIE
2. PLACE THE CENTER HEAD AGAINST OUTSIDE DIAMETER
3. SCRIBE THE CENTERLINE
4. TURN THE CENTER HEAD
5. SCRIBE THE SECOND CENTERLINE
6. REPEAT UNTIL FOUR CENTERLINES SCRIBED

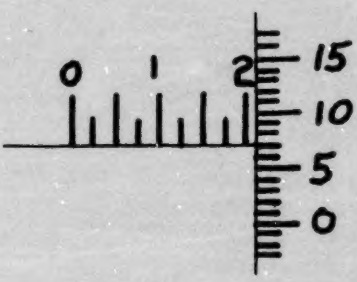
HOW TO USE THE
PROTRACTOR HEAD OF THE COMBINATION SET

. REMOVE BURRS FROM THE WORKPIECE
. LOOSEN THE TURRET CLAMP
. HOLD THE PROTRACTOR BASE AGAINST THE REFERENCE SURFACE
. BRING THE BLADE TO THE WORKPIECE AND ADJUST IT
. TIGHTEN THE CLAMPING SCREW

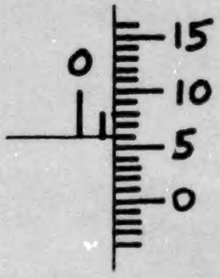




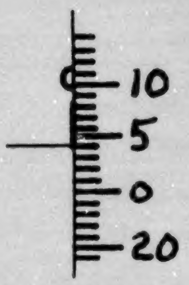
ANSWER: ______________



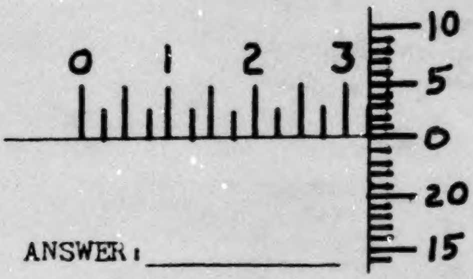
ANSWER: ______________



ANSWER: ______________



ANSWER: ______________


0
1
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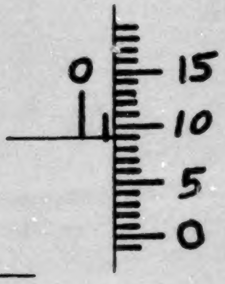
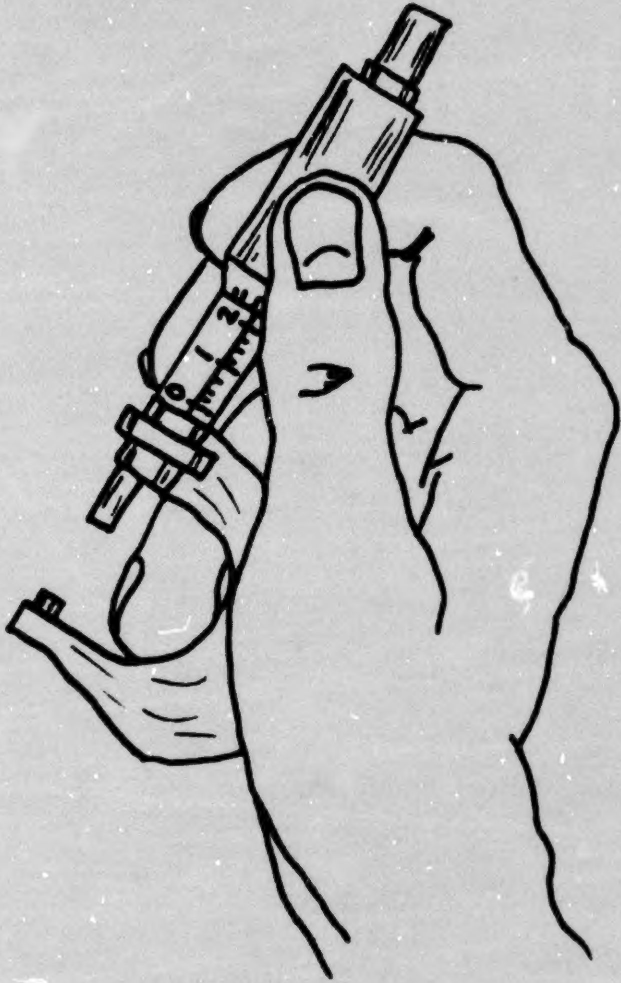
15

ANSWER: ______________



ANSWER: ______________


0
1
2

HOW TO USE THE OUTSIDE MICROMETER

ADJUST THE OPENING SO THAT IT SLIGHTLY LARGER THAN THE ITEM MEASURED
TURN THE RATCHET UNTIL IT CLI
LOCK THE SPINDLE WITH THE LOC
READ THE MEASUREMENT

HOW TO USE THE
OUTSIDE CALIPER

SETTING

1. SET ONE LEG AGAINST THE END
   STEEL RULE
2. MOVE THE SECOND LEG SO THAT
   NEAR TO THE LINE OF MEASUREM

MEASURING

1. HOLD ONE LEG AGAINST A REFER
   POINT
2. ADJUST THE SECOND LEG UNTIL
   CALIPER SLIDES EASILY OVER T
3. MEASURE THE DISTANCE BETWEEN
   TWO LEGS

HOW TO USE THE INSIDE CALIPER

SETTING

1. PLACE ONE LEG AGAINST A STE
2. TURN THE ADJUSTING SCREW UN SECOND LEG IS NEAR THE LINE MEASUREMENT

MEASURING

1. REST ONE LEG AGAINST THE RE POINT
2. ADJUST THE CALIPER UNTIL IT THE POINT OF THE WORKPIECE MEASURED
3. MEASURE THE DISTANCE BETWEE TWO LEGS

HOW TO USE THE
HERMAPHRODITE CALIPER

SETTING

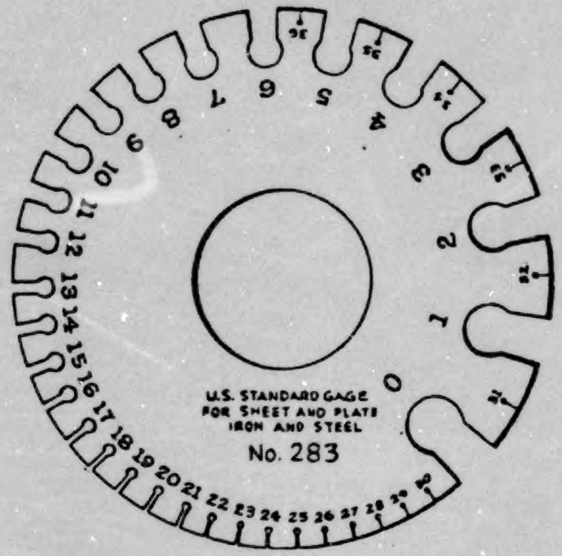
1. PLACE THE LEG AGAINST A REF
   POINT OR SURFACE
2. ADJUST THE POINT

SCRIBING

1. HOLD THE LEG AGAINST THE RE
   SURFACE
2. MOVE BOTH LEGS AT THE SAME
   SCRIBE THE PARALLEL LINE

HOW TO USE THE SLIDE CALIPER

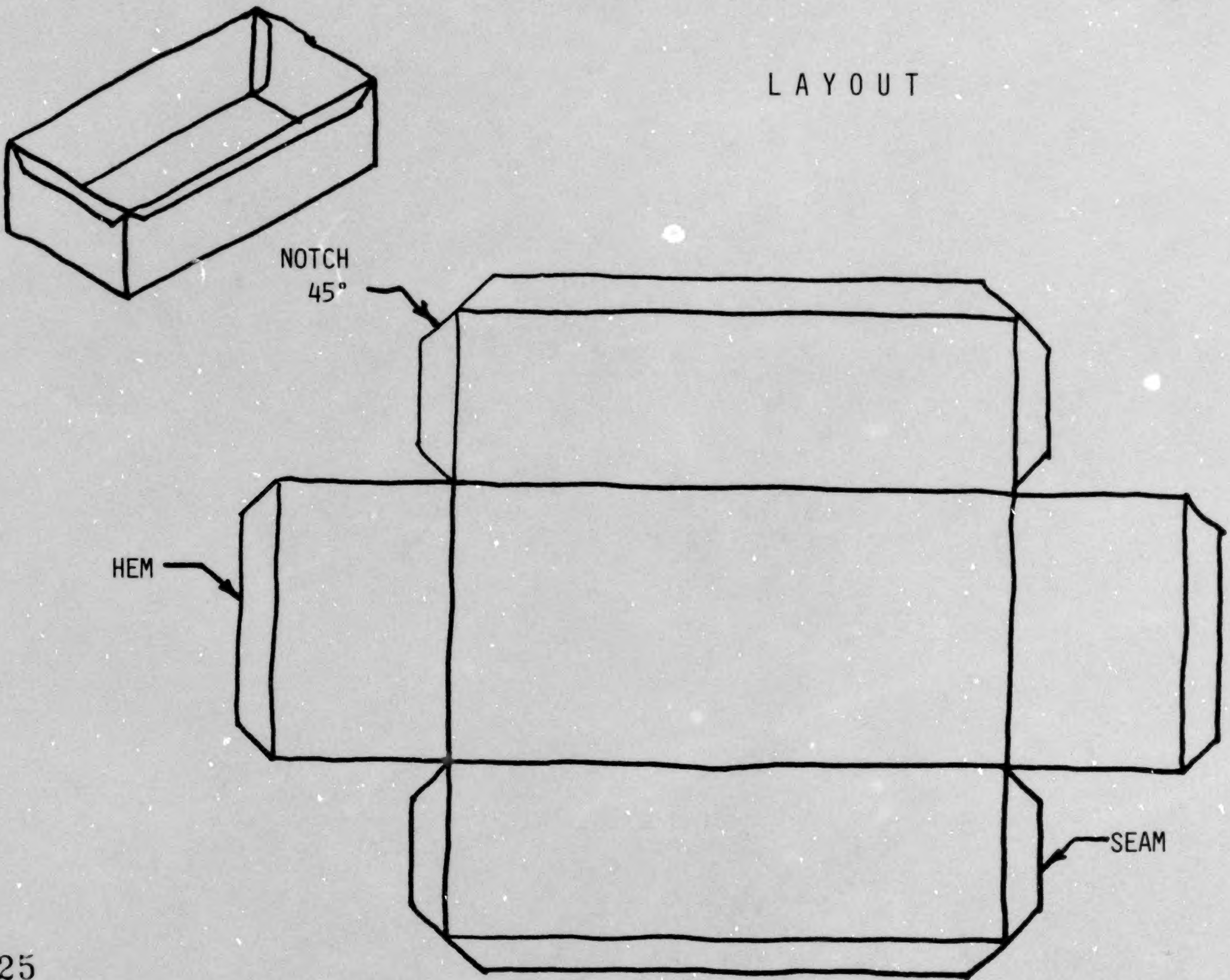
1. RELEASE THE LOCK
2. PLACE ONE LEG AT THE REFER[illegible]E
3. ADJUST THE SECOND LEG TO THE M
   POINT
4. LOCK THE MOVABLE JAW
5. READ THE MEASUREMENT


U.S. STANDARD GAGE
FOR SHEET AND PLATE
IRON AND STEEL
No. 283

HOW TO USE THE SURFACE GAGE

. POSITION THE SPINDLE AND SCRIB
. PLACE THE COMBINATION SET WITH
SQUARE HEAD ON THE SURFACE PLA
. SLIDE THE BLADE UNTIL THE END
THE SURFACE PLATE
. ROUGHLY SET THE SCRIBER
. TURN THE ADJUSTING SCREW TO MO
SCRIBER TO THE DESIRED MEASURE
. SCRIBE THE LINE ON THE WORKPIE

LAYOUT


NOTCH
45°
HEM
SEAM

MW5-25

6

Bench Metal Work

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. correctly use a mallet, soft hammer, and machinist's hammer;
2. correctly use a hand hacksaw, including the replacement of a blade;
3. correctly use a coping saw or jeweler's saw;
4. list the four cuts of files, and identify each;
5. list several different shapes of files, and identify each;
6. list the six classifications of file coarseness, and identify each;
7. correctly use a file for light filing, heavy filing, and draw filing;
8. correctly use a cold chisel;
9. identify various punches;
10. discuss the history of screw threads;
11. correctly tap a through hole and a blind hole;
12. correctly thread a rod;
13. identify various wrenches, and list at least one use for each;
14. correctly use various screwdrivers;
15. identify various pliers;
16. identify various types of washers, and list at least one use of each;
17. identify various types of mechanical fasteners, and list at least one use of each.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

soft hammer
mallet
machinist's hammer
hacksaw
vice jaw caps
coping saw
jeweler's saw
C-clamp
file
safe edge
jeweler's file
file card
draw filing
cold chisel
punches
screw thread
SAE
USS
NC/NF
ASA
Unified Screw Thread System
external thread
internal thread
bolts/screws
tapping
taps
blind hole
tap wrench
tap drill
tap extractor
die
die stock
wrenches
screwdrivers
pliers
parallel clamp
shim
washer
rivets
rivet set
taper pin
cotter pin
keys

TEACHING AIDS

- Overhead projector
- Test Key: 1-C, 2-C, 3-C, 4-B, 5-D, 6-A, 7-A, 8-B, 9-D, 10-B, 11-C, 12-B, 13-B, 14-D, 15-C, 16-D, 17-A, 18-D, 19-B, 20-C, 21-D, 22-D, 23-A, 24-B, 25-C.
- Transparencies: You will find transparencies MW6-1 through MW6-15 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW6-1: How to Use the Machinist's Hammer
MW6-2: Parts of a Hand Hacksaw
MW6-3: How to Use the Hand Hacksaw
MW6-4: Hand Hacksaw Blades are Usually Broken By:
MW6-5: Parts of a File
MW6-6: Filing
MW6-7: How to Use Hand Chisels
MW6-8: Chisel Heads
MW6-9: Thread Information
MW6-10: How to Tap Internal Threads
MW6-11: Causes of Broken Taps
MW6-12: How to Cut External Threads
MW6-13: How to Use Screwdrivers
MW6-14: Screwdrivers
MW6-15: Rivet Setting

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SENTENCE OUTLINE

I. Forming
   A. Soft hammers are used to strike and form hardened steel surfaces.
      1. Soft hammers are made from lead, copper, brass, etc. (Transparency MW6-1)
      2. A mallet is a soft hammer that is made from wood, leather, or rubber.

B. The ball end of the ball-peen hammer is used to shape metal such as in peening (a series of cupped indentations for decoration).

II. Separating

A. Hacksaws are classified as either a pistol-grip or straight-handle, and as either a solid frame or adjustable frame. (Transparency MW6-2)

1. Procedure (Transparency MW6-3)
    - a. The workpiece to be cut should be held tightly in a vise with the part to be cut close to the jaws so it does not chatter.
    - b. Use vise jaw caps to protect polished surfaces.
    - c. When cutting metal, it helps to notch a starting place with a file.
    - d. Remember, a loose blade makes a crooked cut and is likely to twist and break.
    - e. Always begin with a backward stroke.
    - f. You have the correct blade if at least three teeth are cutting the metal at all times.
    - g. Use two hands to saw with a hacksaw: one on the handle, and the other on the front end of the saw frame.
    - h. When sawing, stand with one foot ahead of the other; sway slightly forward and back in addition to moving the arms.
    - i. Press down on the forward stroke, and relax pressure on the return stroke.
    - j. Make about 40 cutting strokes per minute.
    - k. Use the entire length of the blade in cutting—not just a short section.
    - l. Saw blades will break if you twist the saw while using it. (Transparency MW6-4)
    - m. When the blade has almost cut through the metal, support the stock being cut with one hand while finishing the cut with the other.
    - n. Do not complete an old cut with a new blade. Begin a new cut, come into the original cut from the other end, or begin with a new piece of metal.
    - o. Sometimes, in order to complete a long cut, it is necessary to rotate the blade 90° in the frame of the hacksaw.
    - p. If a thin piece of metal must be cut with a hacksaw, place the metal between two pieces of wood, clamp it all in a vise, and saw the wood and metal together.
2. Blades
    - a. Hand hacksaw blades are made of thin, high-grade steel that has been hardened and tempered.
    - b. Blades are made of such metals as carbon steel, tungsten alloy steel, and molybdenum high-speed steel.
    - c. Flexible blades have hardened teeth but a softer back, and are less brittle.
    - d. Blades are commonly made in 8, 10, and 12 inch lengths.
    - e. The length of a saw blade is the distance between the centers of the holes at each end.
    - f. When putting a new blade in the hacksaw, place it so that the teeth point away from the handle.

B. Cutting curved lines is done with a coping saw or jeweler's saw.

1. The work is held with a C-clamp on a board that has a V-shaped notch.
2. The teeth of the blade should point toward the handle.
3. The cutting stroke is downward.

C. A file is a hardened piece of high-grade steel with slanting rows of teeth.

1. History
   a. The first recorded use of a file was 1090 B.C. during the reign of King Saul.
   b. The earliest iron files were used by the Romans.
   c. The first attempt to cut files by machine was in 1490, using a design of Leonardo da Vinci.
   d. In 1765, in England, a water-driven machine was used for cutting files.
   e. The first American machine for cutting files was made in 1836.
2. Information (Transparency MW6-5)
   a. Cuts of files are divided into four groups: (1) single-cut, (2) double-cut, (3) rasp, and (4) curved tooth.
      (1) A single-cut file has single rows of teeth.
      (2) A double-cut file has two sets of teeth which cross each other.
      (3) The teeth of a rasp are unconnected, and are formed by raising small amounts of the surface (used mostly for wood).
      (4) A curved tooth file is used on steel and aluminum.
   b. The teeth of a file are formed by a chisel.
   c. The shape of a file refers to the shape of the cross section; there are hundreds of different shapes.
   d. File coarseness is produced by varying the spacing of the rows of teeth: rough, coarse, bastard, second-cut, smooth, dead smooth.
   e. Special files are made for soft metals: brass, bronze, aluminum, lead, solder, and babbitt.
   f. A safe edge (a file edge without teeth) permits filing against a finished surface.
   g. Most files taper slightly in width; a file without a taper is referred to as a blunt file.
   h. The common sizes of files are 6, 8, 10, and 12 inches (point to heel).
   i. All files should be fitted with handles.
   j. The jeweler's file (needle file) is used for fine filing.
      (1) Jeweler's files are the only files that can be used without separate handles—metal handles are part of the file.
      (2) Jeweler's files are 5 and 6 inches long (including the handle).
3. Procedure (Transparency MW6-6)
   a. The workpiece should be held tightly in a vise with the part to be filed near the vise jaws.
   b. For general filing, the vise should be at elbow height.
   c. If fine, light, delicate filing is to be done, raise the workpiece to eye level.
   d. If a great deal of heavy filing is to be done, lower the workpiece.
   e. Hold the file with one hand on the handle and the palm of the other hand on the point.
   f. When filing, stand with one foot ahead of the other.
   g. Make long, slow, steady strokes by moving the arms and slowly swaying the body back and forth.
   h. Files cut only on the forward stroke.
   i. Exert pressure on the forward stroke, lift on the return stroke, and go slowly.
   j. Keep the teeth of a file free from chips by cleaning with a file card (a specially made wire brush).
   k. Do not rub or strike files against each other.
   l. Use a mill file for draw filing.
      (1) Hold the mill file on the surface, use both hands, and draw the file across the work.

(2) Draw filing produces a fine finish.

D. Cold chisels are used to cut cold metal.

1. Information

a. Chisels are made from high grade steel with hardened and tempered cutting ends.

b. Cold chisels are known by the shapes of their cutting edges: flat, cape, diamond, and round-nose.

c. The cutting angle on most cold chisels is from 50^{0} to 75^{0}.

d. The head of the cold chisel should be tapered but not hardened.

2. Procedure (Transparency MW6-7)

a. Wear goggles when chipping, and use a chip screen.

b. A machinist's hammer (ball-peen hammer) should be used with a chisel.

c. Hold the chisel loosely in the center, and hold the hammer tightly at the end of the handle.

d. The head of the cold chisel should not be permitted to "mushroom"; use the grinding wheel to keep it in shape. Transparency MW6-8

e. The chisel is used in removing rivets by shearing the rivet head.

E. Punches

1. A pin punch has a straight end and is used to drive out cotter pins and tapered pins.

2. A drift punch, or tapered punch, is used to drive out pins and rivets and to arrange holes in a straight line.

F. Screw threads

1. History

a. Screw thread technology was recorded by Archimedes over 2,000 years ago.

b. Leonardo da Vinci designed a screw-cutting machine in 1500.

c. In 1520, Besson developed the first foot-operated lathe spindle for thread chasing (cutting).

d. The Wyatt brothers began mass-producing wood screws in 1750.

e. Sir Joseph Whitworth developed screw thread standards in 1841.

f. William Sellers developed U. S. screw thread standards in 1864; became the United States Standard (USS) in 1868.

g. The thread cutting die was developed in 1887 by A. B. Landis.

h. A fine screw thread series was developed by the Society of Automotive Engineers (SAE) in 1911.

i. The National Coarse (NC) and National Fine (NF) series were approved by the American Standards Association (ASA) in 1935.

j. In 1948, the Unified Screw Thread System was adopted by Great Britain, Canada, and the United States.

2. The winding groove around a bolt, screw, or hole is called a screw thread. (Transparency MW6-9)

a. The thread on a rod is an external thread; in a hole, it is an internal thread.

b. A nut that is turned clockwise to screw it onto a bolt, and a screw that is turned clockwise to enter a hole, have right-hand threads.

c. A nut that is turned counterclockwise to screw it onto a bolt, and a screw that is turned counterclockwise to enter a hole, have left-hand threads.

3. Tapping is the cutting of internal threads. (Transparency MW6-10)

a. Tapping is done with a tool called a tap.

b. A set of taps contains a taper tap, plug tap, and bottoming tap.

c. Start to thread a hole with a taper tap first, then use the plug tap second.

d. Holes that are tapped part of the way through a workpiece are called blind holes.
e. The bottoming tap is used third, but only on blind holes that are threaded to the bottom.
f. A tap wrench holds the tap while tapping.
g. Tap wrenches come in two basic forms, T-handle and straight handle.
h. A tap drill is a term that refers only to a particular size drill that is used prior to tapping, not a "different" drill.
i. A tap extractor is used to remove a broken tap from a hole. (Transparency MW6-11)

4. A die is used to cut an external thread. (Transparency MW6-12)
a. A threading die is a round or square block of hardened steel with a hole containing threads and flutes.
b. Dies are either solid, adjustable, or two-piece.
c. The die stock (die holder) holds the die while threading.

III. Combining

A. Wrenches come in many sizes and shapes: monkey, adjustable end, vise-grip, pipe, open-end, box, socket, spanner, etc.
1. Hollow or socket-type setscrews are turned by a hexagon-shaped offset wrench known as an Allen wrench.
2. A face spanner (2 pins) wrench and a hook spanner (1 pin) wrench are used to turn a special type of nut or bolt.
3. A torque wrench secures nuts and bolts with a uniform, specified force.
4. Wrenches should be made from a high-quality alloy steel that combines strength, toughness, and durability.
5. Electric and pneumatic wrenches enable workers to rapidly assemble and disassemble parts with a minimum of physical effort.
6. Wrenches can be subdivided into two major classifications, adjustable and nonadjustable.

B. The most used types of screwdrivers are flat-head, Phillips head, and offset screwdrivers. (Transparency MW6-13)
1. An offset screwdriver has a bent handle and is used where a straight screwdriver will not reach.
2. The point of the screwdriver is hardened and tempered.
3. Always select a screwdriver whose point fits the size of the slot of the screw. (Transparency MW6-14)

C. Holding devices
1. A machinist's vise is used to clamp parts together while they are being assembled.
2. Pliers come in many shapes: side-cutters, flat-nose, roundnose, needlenose, etc., and are used for gripping, twisting, turning, pulling, and pushing.
3. The C-clamp is shaped like the letter "C" and is used to clamp parts together while they are being assembled.
4. The parallel clamp is used to hold small work.

D. A shim is a thin sheet of metal, plastic, wood, or paper that is placed between two surfaces to keep them a certain distance apart.

E. Washers
1. Washers are used primarily as a bearing surface for bolts, nuts, and screws.
2. Lock washers serve as a spring takeup between bolts or screws and the workpiece, thus preventing loosening from vibration.

F. Mechanical fasteners
1. Bolts and screws are usually used to fasten together parts which have to be separated later.

   a. A bolt is used where both sides of the bolt can be reached; a screw, where only one side can be reached.
   b. Bolts and screws are made in many shapes and sizes: machine bolt, tap bolt, carriage bolt, stove bolt, stud bolt, cap screw, machine screw, setscrew, lag screw, thumbscrew, etc.
      (1) A carriage bolt is usually used to fasten a wooden part to metal.
      (2) A stud bolt has no head and is threaded on both sides.
      (3) Setscrews are used to fasten pulleys and collars on shafts.
      (4) Lag screws are used for heavy work such as fastening a machine to a wooden floor.
      (5) A thumbscrew is used where a screw must be turned by the thumb and finger.
      (6) Self-tapping (sheet metal) screws cut their own threads in soft metal and are used for economical assembly of sheet metal.
2. Rivets are metal pins that look like bolts without threads.
   a. Rivets are made from soft iron or steel, aluminum, copper, and brass.
   b. Rivets come in many sizes and shapes.
   c. Rivets are used to permanently hold pieces together.
   d. Rivets can be eitner solid or tubular.
      (1) The small end of the solid rivet is hammered into the form of a head.
      (2) The small end of the tubular rivet is clinched with a special riveting tool.
   e. A rivet set is a hardened steel tool with a hollow in one end and is used to shape the end of a rivet into a round, smooth head. (Transparency MW6-15)
   f. Rivet sets are made in various sizes and are used for particular sized rivets.
   g. Blind (pop) rivets are inserted and set from the same side of the workpiece with a special riveting tool.

G. Taper pins are made in standard sizes and are used for such jobs as fastening a pulley to a shaft.
H. A cotter pin (cotter key) is a piece of wire that is slipped through a hole in or behind a bolt or nut to keep it from turning.
I. Keys are made in several shapes (square, gib-head, etc.) and are used to keep pulleys and gears from moving on shafts.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Several small pieces of soft aluminum sheet stock
- Various hammers
- Drawing paper, pens
- Various cold chisels with the points ground at different angles
- Small pieces of steel plate
- Calculators

SUGGESTED STUDENT ACTIVITIES

1. Give each student several small pieces of soft aluminum. Ask them to form a right angle in each piece using the corner of the bench top and a (a) mallet, (b) soft hammer, and (c) machinist's hammer. Have the class determine the best/worst hammers for forming metal.

2. Make a sketch of the cross-section shape of several files.
3. Provide the students with several flat, cold chisels—each with a differently ground individual angle. Have the students try each chisel and record the effect each angle has on cutting.
4. Prepare a bulletin board display on the pneumatic chisel.
5. Research how a particular wrench is produced in industry. Report to the class.
6. Ask the students to research other types of screwdriver tips used in industry other than the regular and Phillips.
7. On a display board, have each student attach a different type of fastener, label it, indicate how it is purchased, and list at least one use.
8. Ask students to conduct a hand tool inventory and determine replacement cost.
9. Ask each student to select a different hand tool, make a large drawing of that tool, and label the parts. Display these completed drawings.

Vocabulary Worksheet

1. soft hammer
2. mallet
3. machinist's hammer
4. hacksaw
5. vise jaw clips
6. coping saw
7. jeweler's saw
8. C-clamp
9. file
10. safe edge
11. jeweler's file
12. file card
13. draw filing
14. cold chisel
15. punches
16. screw thread
17. SAE
18. USS
19. NC/NF
20. ASA
21. Unified Screw Thread System
22. external thread
23. internal thread
24. bolts/screws
25. tapping
26. taps

27. blind hole
28. tap wrench
29. tap drill
30. tap extractor
31. die
32. die stock
33. wrenches
34. screwdrivers
35. pliers
36. parallel clamp
37. shim
38. washer
39. rivets
40. rivet set
41. taper pin
42. cotter pin
43. keys

TEST

UNIT 6: BENCH METAL WORK

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Which of the following should not be used to form metal sheet by hand?
A. leather mallet
B. brass hammer
C. machinist's hammer
D. lead hammer

___ 2. Which of the following is not a hacksaw classification?
A. adjustable frame
B. straight handle
C. high grade
D. pistol grip

___ 3. You have the correct blade if how many teeth are in contact with the work at all times?
A. one
B. two
C. three
D. four

___ 4. You should saw at--
A. 30 strokes per minute
B. 40 strokes per minute
C. 50 strokes per minute
D. 60 strokes per minute

___ 5. What part of the blade should you use?
A. the front half
B. the rear half
C. the middle section
D. the entire blade

___ 6. Hacksaw blades are **not** made from--
A. stainless steel
B. carbon steel
C. tungsten alloy steel
D. molybdenum high-speed steel

___ 7. The first recorded use of a file--
A. occurred during the reign of King Saul
B. was by the Romans
C. occurred in 1755 in England
D. was by Leonardo da Vinci

___ 8. An example of a file cut is--
A. half-round
B. curved tooth
C. second-cut
D. dead smooth

___ 9. An example of a file shape is--
A. rasp
B. rough
C. double cut
D. mill

___ 10. An example of a file coarseness is--
A. single cut
B. second cut
C. double cut
D. mill

___ 11. The part of a file that permits filing against a finished surface is the--
A. blunt edge
B. tapered edge
C. safe edge
D. heel

___ 12. The metal handle is part of this file:
A. mill file
B. jeweler's file
C. rasp
D. round file

___ 13. The height of work for general filing is--
A. eye level
B. elbow height
C. slightly lower than elbow height
D. it does not matter

___ 14. For draw filing, you should use a--
A. half-round file
B. square file
C. flat file
D. mill file

___ 15. Which of the following hammers should be used with a chisel?
A. lead hammer
B. copper hammer
C. machinist's hammer
D. mallet

___ 16. Screw threads were first recorded by--
A. Leonardo da Vinci
B. Besson
C. Sir Joseph Whitworth
D. Archimedes

___ 17. Screw thread standards were first developed in 1841 by--
A. Sir Joseph Whitworth
B. the Wyatt brothers
C. Besson
D. William Sellers

___ 18. What became the U.S. Standard threads in 1868 was developed by--
A. Sir Joseph Whitworth
B. the Wyatt brothers
C. Besson
D. William Sellers

___ 19. Which of the following is **not** a part of a tap set?
A. taper tap
B. straight tap
C. plug tap
D. bottoming tap

___ 20. A hexagonal socket setscrew is turned with a--
A. face spanner
B. torque wrench
C. Allen wrench
D. vise-grip

___ 21. Which of the following is considered a wrench?
A. needlenose
B. side cutters
C. roundnose
D. vise-grips

___ 22. Which of these is primarily used to keep two surfaces a certain distance apart?
A. washer
B. parallel clamp
C. shim
D. key

___ 23. Which of these is threaded on both ends (no head)?
A. stud bolt
B. carriage bolt
C. lag screw
D. setscrew

___ 24. Which of these is used to permanently hold two pieces together?
A. keys
B. rivets
C. pins
D. bolts

___ 25. Which of these keeps pulleys and gears from moving on shafts?
A. bolts
B. rivets
C. keys
D. screws

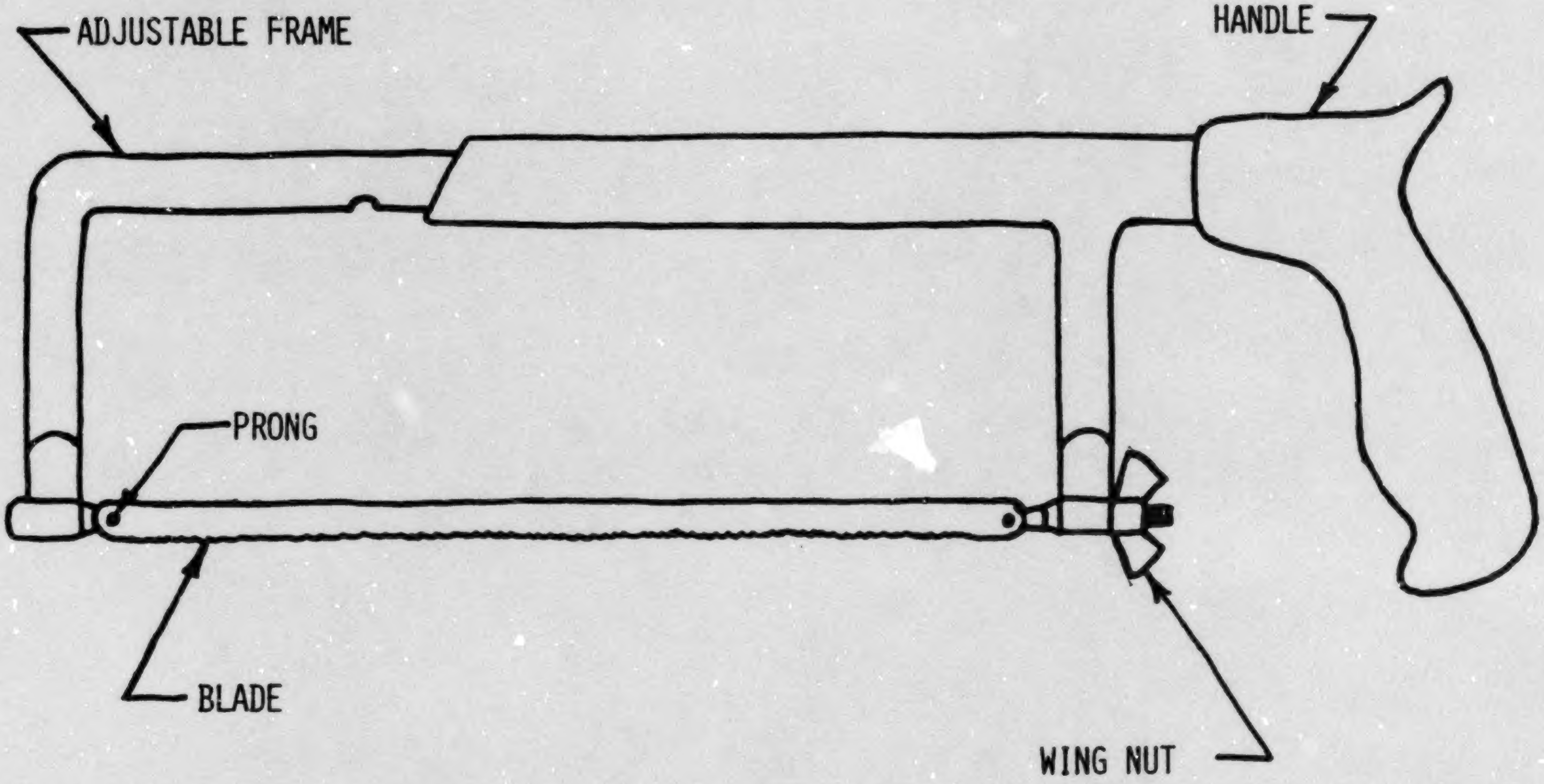
240

HOW TO USE THE
MACHINIST HAMMER

1. GRASP THE HAMMER AT THE END OF THE HANDLE
2. HOLD THE HANDLE TIGHTLY
3. START WITH A LIGHT FIRST BLOW
4. CONTINUE AND STRIKE HEAVY, SOLID BLOWS

MW6-2

PARTS OF A HAND HACKSAW


ADJUSTABLE FRAME
HANDLE
PRONG
BLADE
WING NUT

HOW TO USE THE HAND HACKSAW

1. FILE A SMALL NOTCH AT THE POINT TO BEGIN A CUT
2. HOLD THE HANDLE IN ONE HAND AND PLACE THE BLADE IN THE NOTCH
3. PLACE THE SIDE OF THE THUMB AGAINST THE FLAT SIDE OF THE BLADE TO GUIDE IT
4. PULL THE SAW BACKWARDS TO BEGIN THE CUT
5. GRASP THE FRONT OF THE FRAME WITH THE FREE HAND
6. MOVE THE BODY FORWARD AND BACKWARD WITH THE CUTTING STROKE
7. APPLY PRESSURE ON THE FORWARD STROKE AND RELEASE PRESSURE ON THE RETURN STROKE
8. MAKE EACH STROKE AS LONG AS THE BLADE
9. SLOW DOWN AND RELEASE PRESSURE NEAR THE END OF THE CUT

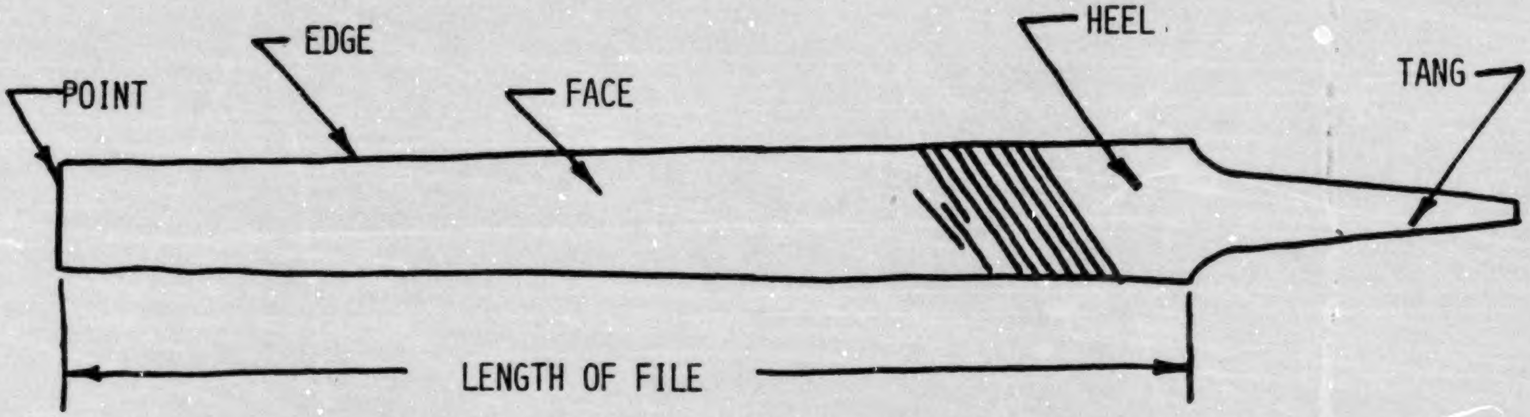
MW6-3

HAND HACKSAW BLADES ARE USUALLY BROKEN BY:

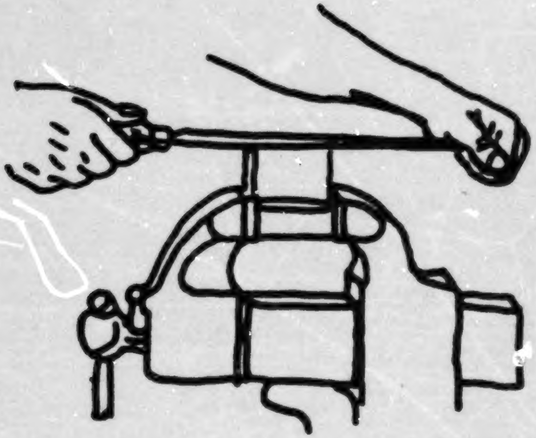
1. LOOSE BLADE
2. LOOSE WORK
3. TOO MUCH PRESSURE
4. BLADE STICKING

MW6-5

PARTS OF A FILE

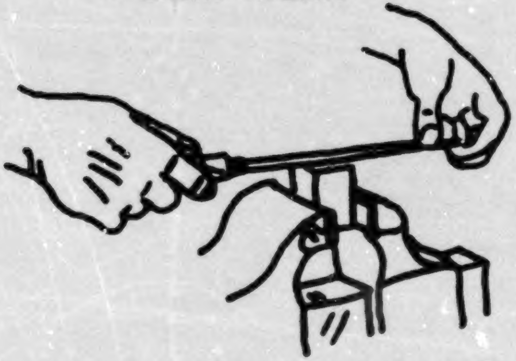

POINT
EDGE
FACE
HEEL
TANG
LENGTH OF FILE

FILING

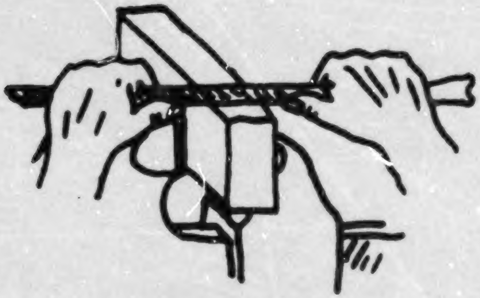


HEAVY FILING

LIGHT FILING



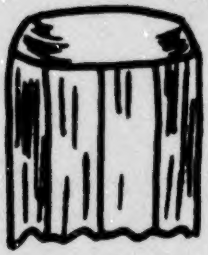
DRAWFILING



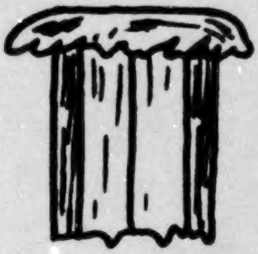
HOW TO USE
HAND CHISELS

1. PLACE THE WORKPIECE IN A HOLDING DEVICE SUCH AS A VISE
2. PLACE A BLOCK UNDER THE WORKPIECE TO KEEP IT FROM MOVING DOWN
3. HOLD THE CHISEL FIRMLY AGAINST THE WORKPIECE
4. CHISEL TOWARD THE SOLID JAW OF THE VISE
5. STRIKE SHARP, HARD BLOWS
6. USE A SMALL AMOUNT OF A LIGHT MACHINE OIL

CHISEL HEADS

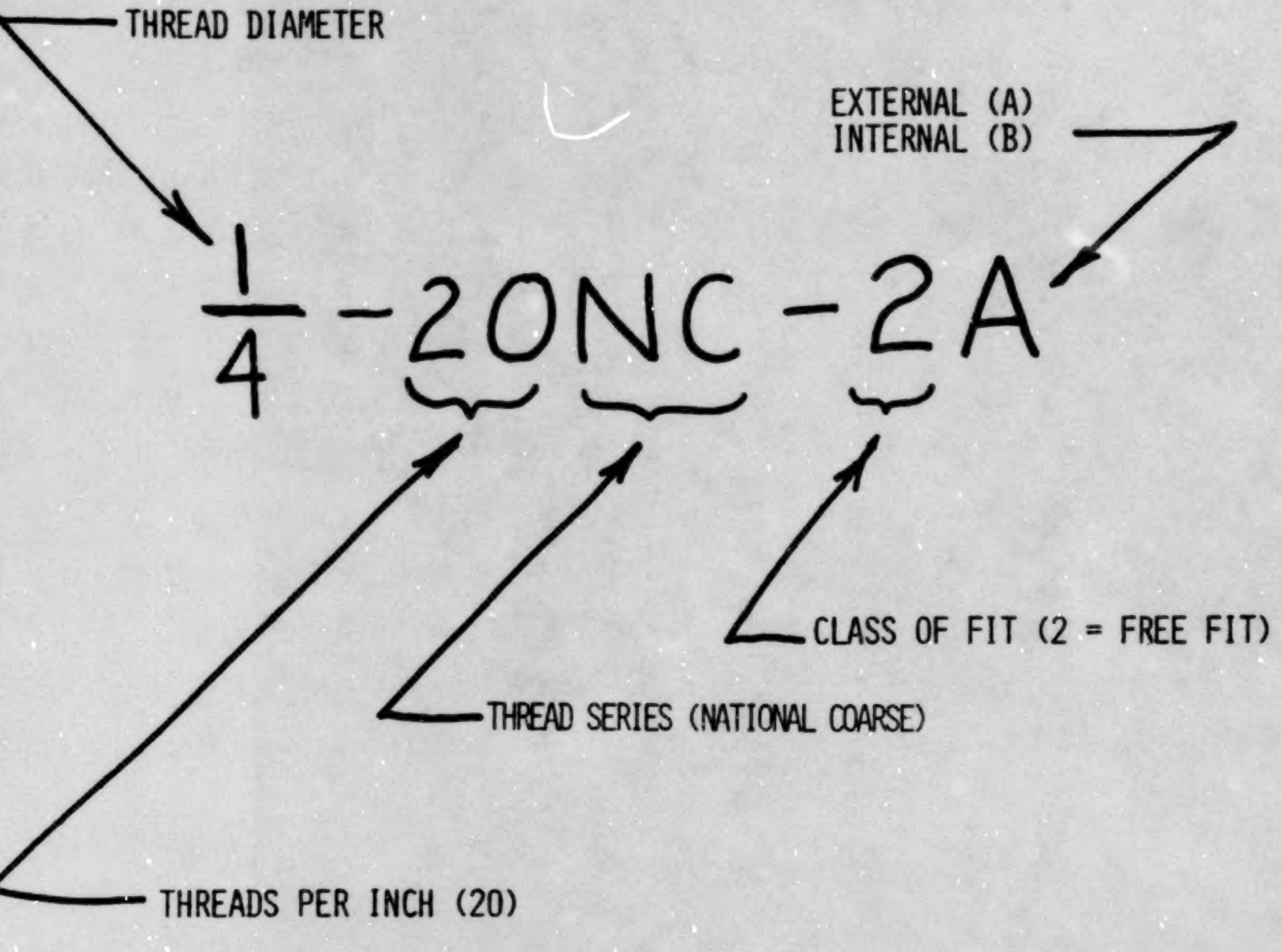


CORRECT



INCORRECT
(MUSHROOM HEAD SHOULD BE REGROUND)

THREAD INFORMATION


THREAD DIAMETER
EXTERNAL (A)
INTERNAL (B)
$\frac{1}{4}$-20NC-2A
CLASS OF FIT (2 = FREE FIT)
THREAD SERIES (NATIONAL COARSE)
THREADS PER INCH (20)

MW6-10

HOW TO TAP INTERNAL THREADS

1. HOLD THE WORKPIECE IN A VISE
2. START WITH A TAPER TAP
3. HOLD THE TAP WRENCH IN ONE HAND AND PLACE THE TAP INTO THE HOLE
4. GUIDE THE TAP WITH THE FREE HAND
5. APPLY SLIGHT DOWNWARD PRESSURE AND TURN THE TAP CLOCKWISE TWO OR THREE TURNS
6. CHECK THE TAP FOR SQUARENESS
7. TURN THE TAP TWO OR THREE TYRNS AND CHECK AGAIN FOR SQUARENESS
8. TURN THE TAP WRENCH WITH BOTH HANDS
9. AS THE TAP CONTINUES TO CUT THREADS, THE PRESSURE MAY BE RELEASED
10. FOR EVERY TWO OR THREE TURNS FORWARD, BACK UP ONE (THIS BREAKS THE CHIPS)
11. LUBRICATE WELL
12. FOLLOW THE TAPER TAP WITH THE PLUG TAP

CAUSES OF BROKEN TAPS

- A HOLE THAT HAS BEEN DRILLED TOO SMALL
- A TAP THAT IS OUT OF SQUARENESS
- TOO MUCH PRESSURE
- LACK OF CUTTING FLUID
- NOT BREAKING THE CHIPS BY BACKING UP THE TAP AFTER EVERY TWO OR THREE TURNS
- TURNING THE TAP AFTER THE BOTTOM OF A BLIND HOLE HAS BEEN REACHED

MW6-12

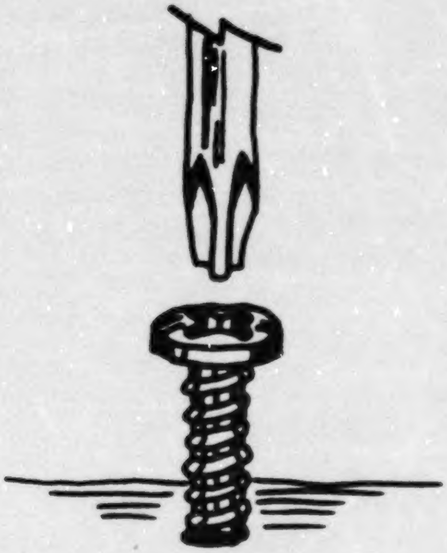
HOW TO CUT EXTERNAL THREADS

1. FILE A CHAMFER ON THE END OF THE WORKPIECE
2. HOLD THE WORKPIECE IN A VISE
3. WITH THE DIE IN A DIESTOCK, POSITION IT ON THE WORKPIECE WITH THE TAPERED END AGAINST THE WORKPIECE
4. APPLY LUBRICANT
5. APPLY A DOWNWARD AND CIRCULAR PRESSURE
6. MAKE TWO OR THREE TURNS THEN BACK UP ONE TURN
7. CHECK FOR SQUARENESS
8. THREAD TO REQUIRED LENGTH
9. BACK OFF THE DIE
10. FILE OFF ANY BURRS

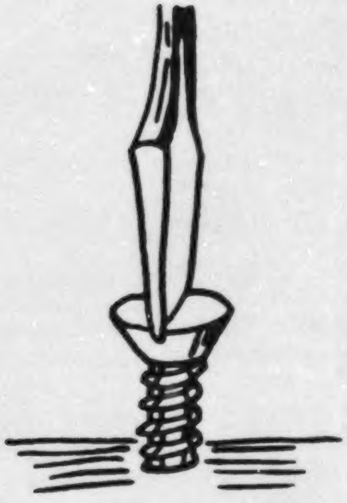
HOW TO USE
SCREWDRIVERS

- HOLD THE HANDLE IN ONE HAND
- GUIDE THE TIP OF THE SCREWDRIVER INTO THE SLOT OF THE SCREW HEAD WITH THE OTHER HAND
- APPLY FORCE TOWARD THE SCREW HEAD
- TURN THE HANDLE CLOCKWISE FOR MOST SCREWS (RIGHT-HAND THREAD) TO TIGHTEN AND COUNTERCLOCKWISE TO LOOSEN

SCREWDRIVERS

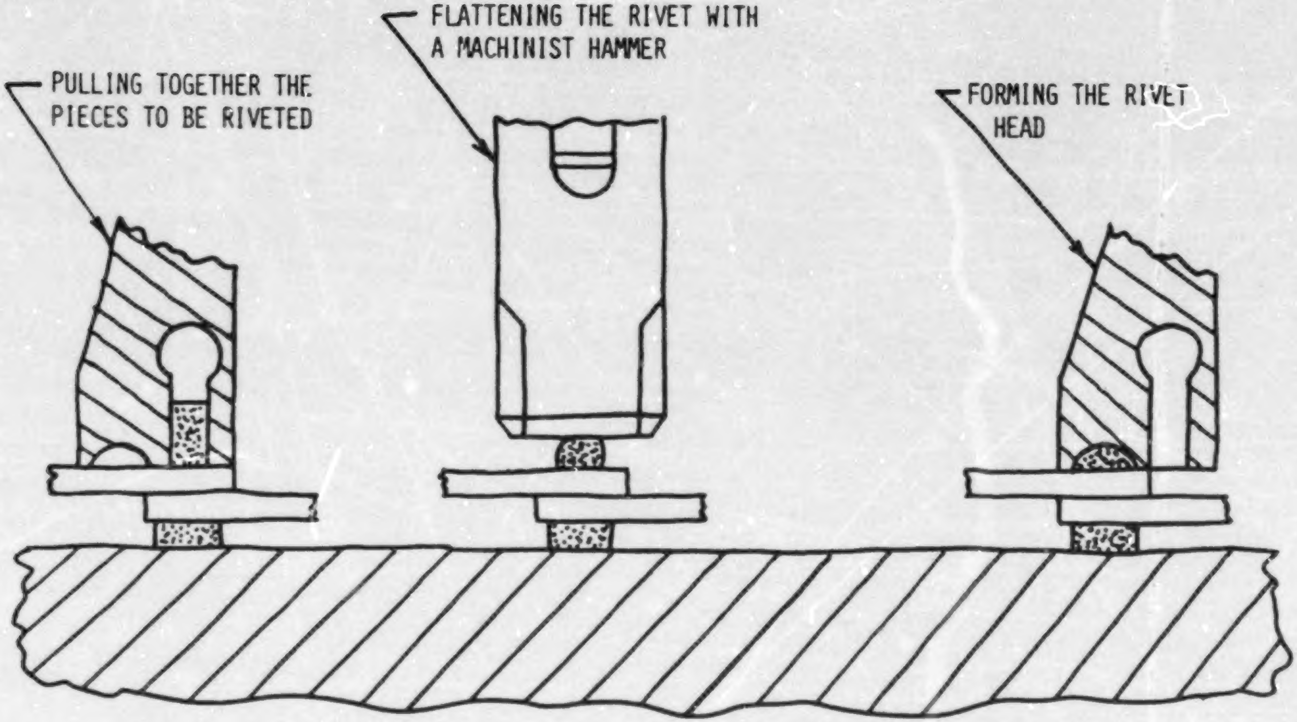


PHILLIPS-HEAD



REGULAR

RIVET SETTING


PULLING TOGETHER THE PIECES TO BE RIVETED
FLATTENING THE RIVET WITH A MACHINIST HAMMER
FORMING THE RIVET HEAD

MW6-15

7

Machine Metal Work

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. correctly drill a hole using a drill press;
2. correctly ream a hole using a drill press;
3. determine the RPM for drilling with both high-speed steel drills and carbon steel drills;
4. determine the RPM for reaming;
5. determine the correct drill diameter for a specified reamer;
6. list various drill press operations, other than drilling and reaming, and explain their significance;
7. locate and name the major components of a drill press;
8. list and identify various types of industrial drilling machines, and state at least one use of each;
9. list the various types of sizes used for drills;
10. correctly insert and remove various sizes of straight shank and tapered shank drills into the drill press;
11. correctly clamp workpieces of various shapes to the drill press table using different holding devices;
12. design a jig and/or fixture for the drill press given a specific production problem;
13. correctly clamp various shapes of stock in the power hacksaw vise;
14. correctly use a power hacksaw;
15. correctly use a horizontal metal cutting band saw;
16. correctly use a vertical metal cutting band saw;
17. correctly use a scroll saw;
18. correctly use an abrasive cutoff saw;
19. correctly use a bench and/or pedestal grinder;
20. list and identify various types of industrial grinding machines, and state at least one specific use of each;
21. correctly use a disc sander;
22. correctly use a belt sander; and
23. correctly use an arbor press.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

drill press
drilling
reaming
counterboring
countersinking
spotfacing
cutting speed
feed
cutting fluid
sensitive drill press
multiple-spindle drilling machine
socket
sleeve
drill drift
safety work holder
V-block
strap clamps
T-bolts
angle plates
parallels
jack screws
step blocks
band saw
scroll saw
abrasive cutoff saw
grinders
cylindrical grinding
centerless grinding
internal grinding
form grinding
surface grinding
flexible shaft hand grinder
offhand grinding

deep-hole drilling machine
radial drill press
turrett drilling machine
electric hand drill
twist drills
shank
swivel blocks
jig
fixture
power hacksaw
reciprocating stroke
floor stand
disc sander
belt sander
arbor press

TEACHING AIDS

- Overhead projector
- Test Key: 1-C, 2-A, 3-D, 4-C, 5-B, 6-D, 7-B, 8-A, 9-C, 10-A, 11-B, 12-C, 13-D, 14-B, 15-D, 16-B, 17-C, 18-D, 19-A, 20-C, 21-B, 22-C, 23-B.

- Transparencies and Handouts: You will find transparencies MW7-1 through MW7-7 and Handouts No. 1 and No. 2 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

  MW7-1: A Drill Press
  MW7-2: How to Use the Drill Press
  MW7-3: Some Common Drill Press Operations
  MW7-4: Workpiece Holding Devices for the Drill Press
  MW7-5: How to Use the Power Hacksaw
  MW7-6: How to Use the Horizontal Cutoff Band Saw
  MW7-7: Grinders

  Handout No. 1: Cutting Speeds (Feet/Minute)
  Handout No. 2: Feeds for Various Drill Sizes

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SENTENCE OUTLINE

I. Drill press (Transparency MW7-1)
  A. Hole making includes: drilling, reaming, counterboring, countersinking, spotfacing, and tapping. (Transparencies MW7-2 and MW7-3)

1. Holes are drilled for putting together projects with rivets, bolts, or screws, and for cutting internal threads.
2. Reaming removes a small amount of metal from a hole, producing a perfectly round, smooth, straight hole held to a specified diameter within very close tolerances.
    a. The amount of material to be left in a predrilled hole to permit accurate reaming is 1/64" smaller than the required finished hole diameter.
    b. The cutting speed for most machine reaming is 60% of that for drilling. (Handouts No. 1 and No. 2)
    c. Machine reamers are fed two to three times deeper per revolution than drills.
    d. Most metals (except cast iron) are reamed using cutting fluid.
3. Holes can be counterbored to permit screw heads to set below the surface of a workpiece.
4. Countersinking refers to the machining of a cone-shaped opening in the outer surface of a hole (called a countersunk hole), usually for flat-head screws.
5. Spotfacing produces a flat surface (usually on a rough surface casting) on the top of a drilled hole for a screw head to set against.

B. Drilling machines
1. The simplest conventional drilling machine is the sensitive drill press.
    a. Simple drilling machines are usually of the bench or floor type.
    b. Four major components of a sensitive drill press are (1) base, (2) work table, (3) head, and (4) drive mechanism.
2. The standard upright drill press is similar to a sensitive drill press except it is of heavier construction.
3. The multiple-spindle drilling machine is a mass-production machine with several individually adjustable spindles.
    a. Mass production uses multiple-spindle drilling machines for rapid production of many holes.
    b. A gang drill is a type of multiple-spindle machine in which the workpiece begins at the first spindle, moves to the second spindle for the second operation, moves to the third spindle for the third operation, etc.
4. On a deep-hole drilling machine, the drill is held stationary and the work is rotated.
5. On the radial drill press, the arm and tool head may be swiveled around a large segment of the column.
6. The turrett drilling machine has up to ten separate heads, which eliminates the necessity of tool changing between operations.
7. The electric hand drill is used for drilling small holes.
8. Almost any drilling machine can be adapted with numerical control or computer numerical control.

C. Unconventional drilling machines
1. Unconventional hole making machines do not use drills, reamers, etc., can penetrate harder materials such as ceramics, and can inexpensively produce irregular-shaped holes.
2. Unconventional drilling machines include (a) electrical discharge machinery (EDM), (b) electrochemical machining (ECM), (c) ultrasonic machining, and (d) laser beam machining (see Unit 1 for additional information).

D. Common drills are known as twist drills.
1. Drills are made from (a) high-speed steel, (b) carbon steel, (c) cobalt high-speed steel, and (d) tungsten carbide.

2. Drill sizes come in (a) numbers (80 to 1), (b) letters (A to Z), (c) inches and fractions of an inch, and (d) metric.
  a. The size of numbered drills varies from 0.228" (#1) to 0.0135 (#80).
  b. The size of lettered drills varies from 0.234" (A) to 0.413 (Z).
  c. The most used fractional drills are from 1/64" to 1/2" in diameter.
  d. The drill size is stamped on the shank.
3. Twist drill shanks are either straight or tapered.
  a. Straight shank drills are usually held in a drill chuck.
  b. The tapered shank drill fits directly into the drill press spindle.
  c. When the tapered shank of the drill is smaller than that of the drill press spindle, an adapter called a sleeve is used.
  d. A fitted tapered socket fits into the drill press spindle and holds a tapered shank twist drill, which provides a method of extending the length of the cutting tool.
  e. A drill drift is a flat, tapered metal bar that is used to remove a tapered shank twist drill or a drill chuck from the drill press spindle.

E. Holding devices (Transparency MW7-4)
1. The drill press vise is normally (a) standard, (b) angle, or (c) universal.
2. A safety work holder fits around the column of the drill press.
3. A V-block is used to hold cylindrical parts for drilling.
4. Irregular-shaped parts can be held on the drill press with strap clamps and T-bolts.
5. Additional holding accessories include (a) angle plates, (b) parallels, (c) jack screws, (d) step blocks, (e) packing blocks, (f) shims, and (g) universal swivel blocks.
6. A drill fixture is a holding device specifically designed to hold a particular part in place.
7. A drill jig is similar to a fixture except that it also has bushings which guide the cutting tool to a precise location.

F. Calculations
1. To calculate the RPM (revolutions per minute) of the drill press, use the following formula:

$$\text{RPM} = \frac{\text{cutting speed} \times 4}{\text{drill diameter}}$$

  a. Cutting speed is the surface feet that the circumference of a drill travels in one minute.
  b. The smaller the drill size, the higher the speed required.
2. Feed is the depth the drill travels per each revolution.

II. Power saws (Transparency MW7-5)
A. Power hacksaws are used to cut sections of materials such as rods and bars to length.
1. Power hacksaws can be used to cut castings and forgings.
2. Power hacksaws have a reciprocating stroke.
3. The power hacksaw is similar to hand hacksawing.
4. Power hacksaw blades are thicker, wider, and coarser than those for a hand hacksaw.
  a. Power hacksaw blades are made from high-speed steels or high-speed alloy steels.
  b. Power hacksaw blades range from 12" to 24".
5. Use a floor stand to support long stock.

- B. Band saws (Transparency MW7-6)
    - 1. The metal cutting horizontal band saw is used to cut sections of materials such as rods and bars to length.
        - a. Continuous feed is possible because the blade revolves in one direction only.
        - b. The horizontal band saw cuts faster than the power hacksaw.
    - 2. A vertical band saw is used for (a) straight line cuts, (b) angular cuts, and (c) curved line cuts.
    - 3. A portable band saw may be carried to the job.
- C. The scroll saw (jigsaw) is used to cut curves in thin soft metals.
- D. The abrasive cutoff saw is a metal-cutting circular saw that cuts by means of a rapidly revolving thin abrasive wheel.

III. Grinders (Transparency MW7-7)

- A. Grinding is the process of cutting away particles of a material. A grinder is used for grinding metal and for sharpening tools.
    - 1. The bench grinder is mounted on the bench.
    - 2. The pedestal (floor) grinder is mounted on a pedestal.
    - 3. In cylindrical grinding, the work is mounted between centers and rotates while in contact with the grinding wheel.
    - 4. In centerless grinding, the piece is positioned on a work support block and is fed automatically between a regulating or feed wheel and the grinding wheel which does the cutting.
    - 5. Internal grinding is done to secure a fine surface finish and accuracy on internal diameters.
    - 6. In form grinding, the grinding wheel is shaped to produce the required design on the work.
    - 7. Flat surfaces are ground on a surface grinder.
    - 8. Portable grinders use abrasives that are glued to flexible backings called grinding discs.
    - 9. Light grinding jobs, like some deburring, can be done with flexible shaft hand grinders.
- B. Grinding done on a bench grinder and a pedestal grinder is called offhand grinding.
    - 1. Offhand grinding requires that the workpiece be held and guided by hand.
    - 2. Each grinding wheel has an adjustable tool rest.
        - a. The tool rest is kept as close to the grinding wheel as possible.
        - b. The workpiece is steadied on the tool rest.
    - 3. Wheel guards enclose approximately three-fourths of the wheel.
    - 4. Use the grinder water pot to periodically dip the workpiece into, to keep it cool while grinding.
    - 5. Dressing is the process of reconditioning a grinding wheel.

IV. Disc/belt sanders

- A. Disc sanders and abrasive belt sanders are common machine tools in the metalworking laboratory.
- B. The disc sander produces true edges and ends as well as arcs and circles.
- C. When using the disc sander, keep the workpiece flat on the table, and the hands away from the disc.
- D. Abrasive belt sanders remove rough edges and produce a finer finish than disc sanders.

V. An arbor press is used for pressing parts of machinery together or forcing them apart.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)
- Calculator
- Drills (number, letter, fraction, metric)
- Various drill press holding devices
- Cutting fluid
- Drawing paper, pens, pencils
- Basic drafting equipment

SUGGESTED STUDENT ACTIVITIES

1. Ask the students to calculate the RPM and feed rate for drilling and reaming various sizes of holes in different metals.
2. Have the students correctly operate the drill press.
3. Give the students a variety of shapes of workpieces. Have them correctly fix each workpiece to the drill press table using various holding devices.
4. Provide students with a problem of designing a jig and/or fixture for the mass production of a product. Have them work in small groups and compare the results.
5. Make an audio tape recording of a sharp and a dull drill being used on various metals. See if the students can recognize any difference in the sounds and which holes are being drilled with sharp drills and which with dull drills.
6. Ask students to correctly operate the power hacksaw.
7. Ask students to correctly operate the power band saw.
8. Ask students to correctly operate the disc sander.
9. Ask students to correctly operate the belt sander.
10. Using two scales attached to the arbor press, have students determine the amount of force necessary on the handle to exert a given amount of force on the press head.

Vocabulary Worksheet

1. drill press
2. drilling
3. reaming
4. counterboring
5. countersinking
6. spotfacing
7. cutting speed
8. feed
9. cutting fluid
10. sensitive drill press
11. multiple-spindle drilling machine
12. deep-hole drilling machine
13. radial drill press
14. turrett drilling machine
15. electric hand drill
16. twist drills
17. shank
18. socket
19. sleeve
20. drill drift
21. safety work holder
22. V-block
23. strap clamps
24. T-bolts
25. angle plates
26. parallels

27. jack screws
28. step blocks
29. packing blocks
30. swivel blocks
31. jig
32. fixture
33. power hacksaw
34. reciprocating stroke
35. floor stand
36. band saw
37. scroll saw
38. abrasive cutoff saw
39. grinders
40. cylindrical grinding
41. centerless grinding
42. internal grinding
43. form grinding
44. surface grinding
45. flexible shaft hand grinder
46. offhand grinding
47. dressing
48. disc sander
49. belt sander
50. arbor press

TEST

UNIT 7: MACHINE METAL WORK

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Which of the following is generally not done on the drill press?
A. counterboring
B. spotfacing
C. broaching
D. countersinking

___ 2. Generally, the size of the drill used prior to reaming is how much smaller?
A. 1/64"
B. 1/32"
C. 1/16"
D. 1/8"

___ 3. The cutting speed for most machine reaming is what percentage of the cutting speed for drilling?
A. 30%
B. 40%
C. 50%
D. 60%

___ 4. How does the feed for reaming compare to that for drilling?
A. one-half as fast
B. same rate
C. two to three times as fast
D. three to four times as fast

___ 5. Which of the following metals generally does not require cutting fluid while being reamed?
A. wrought iron
B. cast iron
C. steel
D. low carbon steel

___ 6. Which of the following is done to permit a screw head to set below the surface of the workpiece?
A. spot facing
B. countersinking
C. reaming
D. counterboring

___ 7. The machining of a cone-shaped opening in the outer surface of a hole, usually for flat-head screws, is called--
A. spotfacing
B. countersinking
C. reaming
D. counterboring

___ 8. A technique that produces a flat surface on the top of a drilled hole for a screw head to set against is--
A. spotfacing
B. countersinking
C. reaming
D. counterboring

___ 9. The simplest conventional drilling machine is the--
A. deep-hole drilling machine
B. gang drilling machine
C. sensitive drill press
D. radial drill press

___ 10. A mass-production machine with several individually adjustable spindles is the--
A. gang drill press
B. radial drill press
C. turrett drilling machine
D. deep-hole machine

___ 11. The drill is held stationary and the work rotates when using the--
A. radial drill press
B. deep-hole drilling machine
C. gang drill press
D. turrett drilling machine

___ 12. Common twist drills are not made from--
A. tungsten carbide
B. cobalt high-speed steel
C. molybdenum alloy steel
D. carbon steel

___ 13. The most used fractional drills range in size from--
A. 1/4" to 3/4"
B. 1/8" to 3/4"
C. 1/2" to 1"
D. 1/64" to 1/2"

___ 14. Straight shank drills are normally held in a--
A. sleeve
B. drill chuck
C. adapter
D. fitted tapered socket

___ 15. A tapered shank twist drill is removed from the drill press spindle using a--
- A. fitted tapered socket
- B. adapter
- C. sleeve
- D. drill drift

___ 16. A drill press holding device that fits around the column of the drill press is the--
- A. T-bolt
- B. safety work holder
- C. universal vise
- D. jack screw

___ 17. Cylindrical parts for drilling are held by a--
- A. T-bolt
- B. drill press vise
- C. V-block
- D. angle plate

___ 18. Which device not only holds the part on the drill press, but also guides the drill to a precise location?
- A. angle plate
- B. fixture
- C. step block
- D. jig

___ 19. Which of the following uses a reciprocating stroke?
- A. power hacksaw
- B. horizontal band saw
- C. abrasive cutoff saw
- D. grinder

___ 20. A saw that cuts sharp curves in thin, soft metals is the--
- A. portable band saw
- B. vertical band saw
- C. scroll saw
- D. abrasive cutoff saw

___ 21. The industrial grinding process in which the workpiece is mounted between centers and rotates while in contact with the grinding wheel is called--
- A. internal grinding
- B. cylindrical grinding
- C. form grinding
- D. centerless grinding

___ 22. The grinding process in which the grinding wheel is shaped to produce the required design on the workpiece is called--
- A. cylindrical grinding
- B. surface grinding
- C. form grinding
- D. centerless grinding

___ 23. Reconditioning a grinding wheel is known as--
A. honing
B. dressing
C. edging
D. facing

HANDOUT NO. 1

CUTTING SPEEDS

(Feet/Minute)

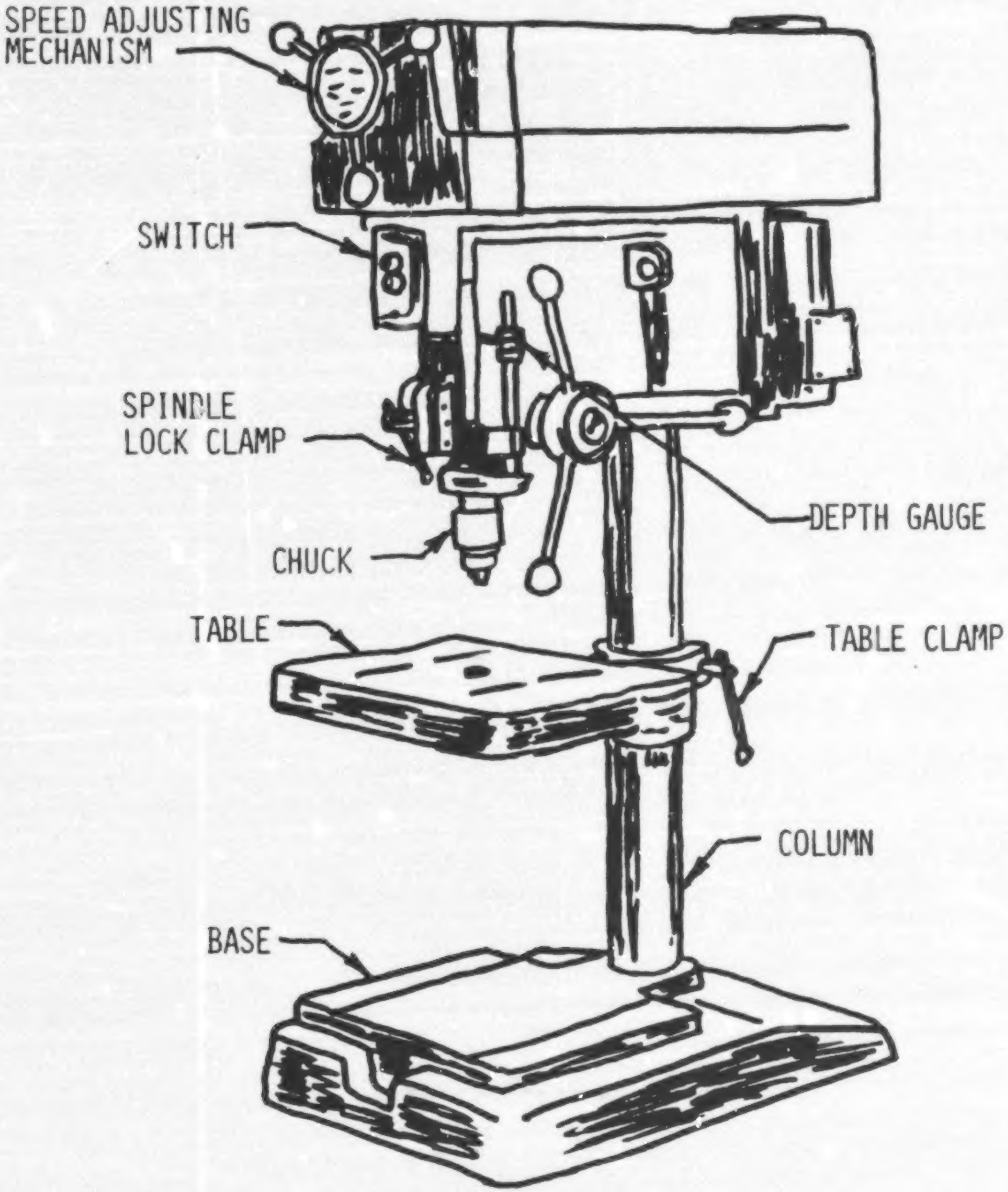
	OPERATION		
	DRILLING		REAMING
	HIGH-SPEED STEEL	CARBON STEEL	HIGH-SPEED STEEL
ast Aluminum, Magnesium	300	120	300
luminum Stock	250	100	250
rass	175	50	175
ow-Carbon Steel	80	30	50
edium-Carbon Steel	60	25	30
igh-Carbon Steel	50	20	25
ainless Steel, Bronze, Copper	100	40	50
ray Cast Iron	70	30	45

HANDOUT NO. 2

Feeds for Various Drill Sizes

DRILL SIZE (inches)	FEED
Small # sizes to 1/8	0.001 to 0.002
1/8 to 1/4	0.002 to 0.004
1/4 to 1/2	0.004 to 0.007
1/2 to 1	0.007 to 0.015
Larger than one inch	0.015 to 0.025

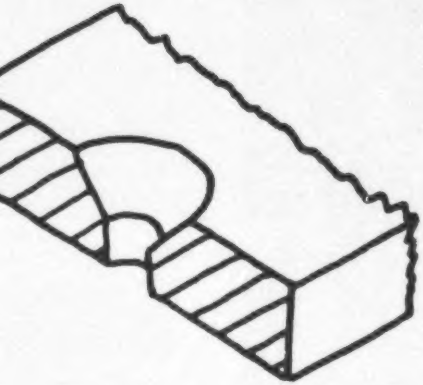
A DRILL PRESS


SPEED ADJUSTING MECHANISM
SWITCH
SPINDLE LOCK CLAMP
DEPTH GAUGE
CHUCK
TABLE
TABLE CLAMP
COLUMN
BASE

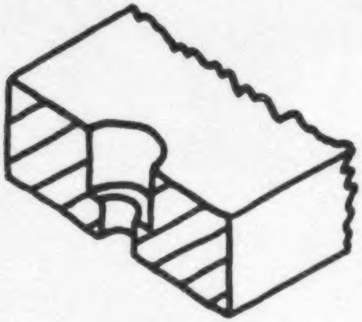
HOW TO USE THE
DRILL PRESS

1. SET THE SPEED
2. ALIGN THE HOLE WITH THE DRILL
3. CLAMP THE WORK-HOLDING DEVICE TO THE TABLE
4. START THE MACHINE
5. APPLY SLIGHT FORCE TO BEGIN THE DRILL
6. APPLY CUTTING FLUID
7. FEED THE DRILL UNTIL IT IS ABOUT ONE DIAMETER DEEP, THEN BACK OUT AND LET THE CUTTING FLUID FILL THE HOLE
8. COMPLETE THE OPERATION (IF A BLIND HOLE IS BEING DRILLED, READ THE DEPTH FROM THE SCALE ON THE DRILL PRESS HEAD)
9. STOP THE MACHINE AND CLEAN WITH A BRUSH
10. REMOVE ANY BURRS

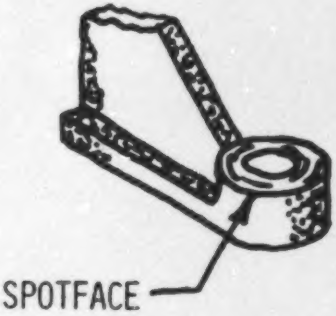
SOME COMMON
DRILL PRESS OPERATIONS



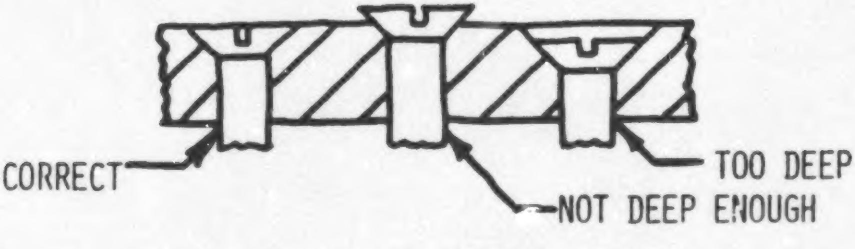
COUNTERSINKING



COUNTERBORING



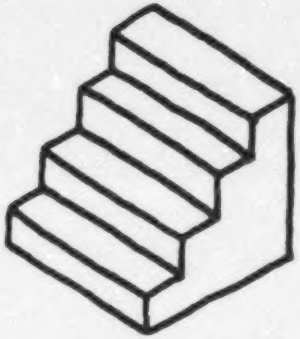
SPOTFACING

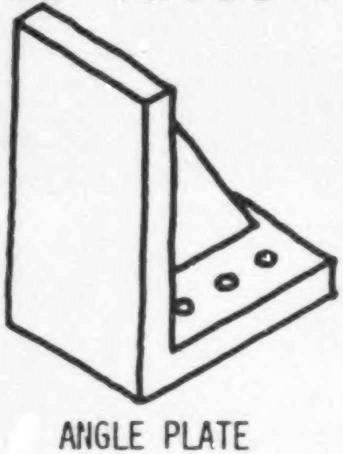

CORRECT
TOO DEEP
NOT DEEP ENOUGH

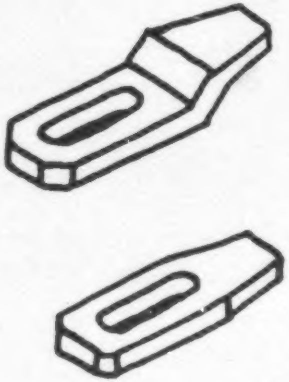
A "CORRECT" COUNTERSUNK HOLE

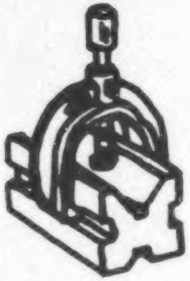
WORKPIECE HOLDING DEVICES FOR THE DRILL PRESS

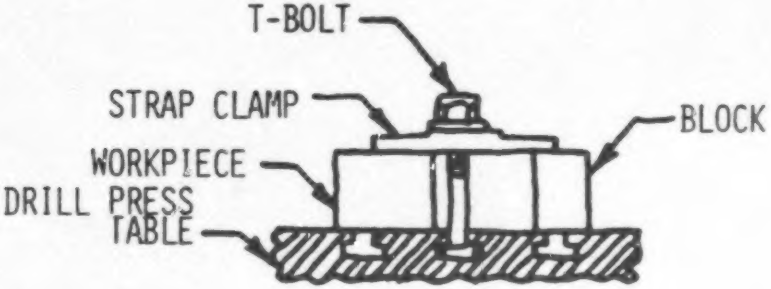
MW7-4


STEP BLOCK


ANGLE PLATE


STRAP CLAMPS


V-BLOCK & U-CLAMP


T-BOLT
STRAP CLAMP
BLOCK
WORKPIECE
DRILL PRESS TABLE
T-BOLT

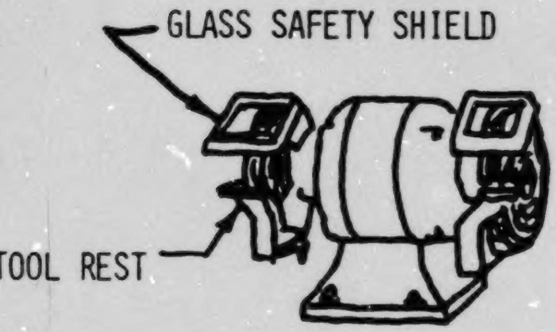
HOW TO USE THE POWER HACKSAW

1. SET AT CORRECT SPEED
2. POSITION THE WORK STOP
3. PLACE THE WORKPIECE IN THE VISE
4. SUPPORT ANY LONG STOCK ON A FLOOR STAN
5. POSITION THE CUTTING FLUID NOZZLE
6. TURN THE POWER ON
7. WITH THE HANDLE, POSITION THE FRAME
8. WITH THE CLUTCH, ENGAGE THE FRAME
9. REMOVE ANY BURRS

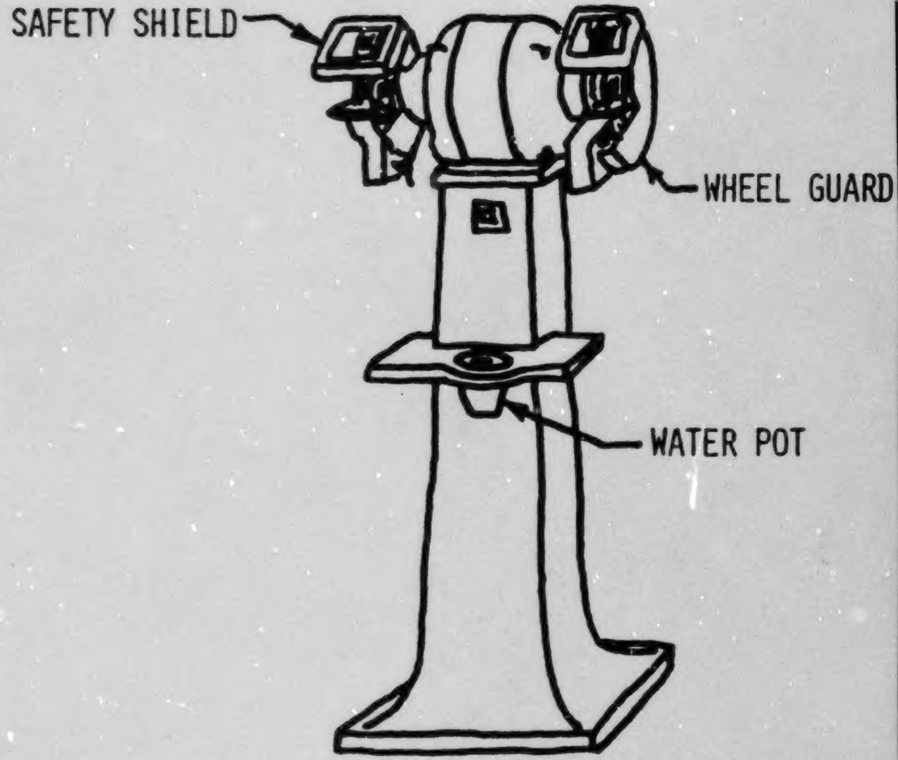
HOW TO USE THE
HORIZONTAL CUTOFF BANDSAW

1. SET THE MACHINE FOR THE CORRECT SPEED AND FEED
2. POSITION THE TWO SAW ARMS AS CLOSE TO THE WORKPIECE AS POSSIBLE
3. POSITION THE WORKPIECE IN THE VISE
4. POSITION THE COOLANT NOZZLE
5. TURN THE MACHINE ON
6. REMOVE ANY BURRS

GRINDERS


GLASS SAFETY SHIELD
TOOL REST

BENCH GRINDER


GLASS SAFETY SHIELD
WHEEL GUARD
WATER POT

PEDESTAL GRINDER

8

Forging/Heat Treatment

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. tell why forged parts are stronger than machined parts;
2. explain the difference between drawing and upsetting;
3. list various types of industrial forging processes, and explain how they operate;
4. light a forge and/or a furnace;
5. distinguish between the various forging tools, and explain their uses;
6. correctly use various forging tools;
7. explain what occurs during the heat treatment of metal;
8. correctly anneal, harden, and temper metal; and
9. correctly case-harden metal.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

forging
smithing
upsetting
drawing
drop forging
open die forging
hydraulic press forging
plastic
cold heading
forge
heat treating furnace
blacksmith's hammer
set hammer
swaging hammer
forging punches
sledge
anvil
tongs
hardy
flatter
fuller
swage
pyrometer
annealing
hardening
tempering
case hardening
vermiculite
quenching
brine

TEACHING AIDS

- Overhead projector
- Test Key: 1-D, 2-C, 3-B, 4-C, 5-A, 6-D, 7-B, 8-A, 9-A, 10-D, 11-C, 12-C, 13-D, 14-B, 15-D, 16-A, 17-B.
- Transparencies and Handout: You will find transparencies MW8-1 through MW8-4 and Handout No. 1 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW8-1: Methods of Heating Metal
MW8-2: Lighting the Forge
MW8-3: Anvil Tools
MW8-4: Parts of the Anvil

Handout No. 1: Approximate Temperature Indicated by Colors (Steel)

SUGGESTED REFERENCES

Feirer, J. L., and Lindbeck, J.R. Basic Metalwork. Peoria, Ill.: Charles A. Bennett, 1978.
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Groneman, C. H., and Grannis, G. F. Exploring the Industries. Albany, N. Y.: Delmar Publishers, 1981.
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Metalworking. Encino, Calif.: Glencoe Publishing Company, Inc., 1978.
Miller, R., and Morrisey, T. J. Metal Technology. Indianapolis, Ind.: Howard W. Sams, 1975.
Miller, W. R., et al. Metalworking. Bloomington, Ill.: McKnight, 1978.
Walker, J. R. Exploring Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.
Walker, J. R. Modern Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.

SENTENCE OUTLINE

I. Forging is a forming process.
  A. Forging is a process that has been used for centuries.
    1. Early humans used forging to make cookingware, weapons, and farming tools.
    2. In some early societies, the practice of smithing was considered to be magic, and some of these who forged the hot metal were priests.
  B. Forging is the process of using force to shape heated metal. (Transparencies MW8-1 and MW8-2)
    1. Almost all metals can be forged.
    2. Forged parts are stronger than machined parts because where machining cuts through the grain, forging causes the grain to follow the shape of the workpiece.
    3. Forging produces much less scrap than machining.
    4. Forging improves metal by refining the grain structure.
    5. Strong parts of complex shape can usually be forged at less cost than they can be machined.
    6. Forging may be done with or without the use of dies.
    7. Upsetting increases the thickness (for example, a bolt head).
    8. Drawing out increases the metal's length, width, or both.
    9. Forged products include:
      a. screws
      b. bolts
      c. connecting rods
      d. gear blanks
      e. hub caps
      f. tools
      g. aircraft parts
      h. window pulls
      i. crankshafts
  C. Industrial forging is usually done in large presses.
    1. Drop forging is the most used industrial forging process.
      a. The drop forging industrial machine has a heavy frame and uses a falling hammer that strikes an anvil to forge the part to be shaped.
      b. Drop forging hammers the metal between closed dies.

        c. Half of the die is attached to the hammer and half to the anvil.
        d. Dies are made from specially hardened, high-strength steel.
        e. The drop forge uses various methods to apply the pressure: (a) gravity, (b) steam, or (c) air.
        f. Excess metal which is squeezed out between the dies is called flash.
    2. In the open die forge, the work is manipulated by hand.
    3. The hydraulic press forging machine uses hydraulic pressure to force two dies together.

D. Forging can be done with hot or cold metal.
    1. Forging is usually understood to mean hot forging.
    2. When metal is heated so that it can be shaped by hammering and pressing, it is said to be plastic in nature.
    3. Cold heading refers to upset forging done to cold metal.

E. Hand forging is only used today for repair and fabrication of unique, one-of-a-kind items.
    1. A gas-fired forge, or furnace, is usually used to heat the metal, although coal and electricity are also used.
    2. To forge metal, it must be heated well above its critical temperature—between bright red and yellow.
    3. In addition to goggles and face shield, it is a good idea to wear leather gloves, heavy shoes, and an apron while forging.

F. Special tools and equipment are needed for forging. (Transparency MW8-3)
    1. Forging hammers come in a variety of shapes and sizes.
        a. The hand hammer (blacksmith's hammer) is the general-purpose forging hammer.
        b. The set hammer has a smooth, flat face (1¼" square) and is used to make square corners and shoulders.
        c. Swaging hammers are used to form round shapes.
        d. Forging punches are hammers that are used to punch holes.
        e. A sledge is a heavy hammer (8 to 20 pounds) with a long handle that is swung with both hands.
        f. While a 1½ to 2½ pound hammer is suitable for light work, a 3 pound hammer should be used for heavier work.
    2. Anvils (Transparency MW8-4)
        a. Anvils weigh from a few pounds to over 300 pounds.
        b. The anvil is made from cast iron with a hardened steel face.
        c. The horn of the anvil is used to form round shapes.
        d. The face of the anvil is used to form flat shapes.
        e. The hardy hole is used to hold certain tools.
        f. The pritchel hole is used to bend small rods.
        g. An anvil should be securely fastened to a wood or metal base with the anvil face about 30" above the floor.
    3. Tongs are used to hold the hot metal while it is being formed on the anvil.
        a. Tongs are available in a variety of shapes and sizes.
        b. Never leave the tongs in the fire with the work.
    4. A hardy is used to cut the metal on the anvil.
    5. A forging flatter is used to form flat surfaces.
    6. Fullers are tools used to shape notches and grooves.
    7. A swage block is a heavy block of cast iron (or steel), about 4" thick and 20" square, that has many grooves and holes of various shapes and sizes and is used to form the metal into different shapes.

II. Heat treatment is the controlled heating and cooling of metal to obtain the desired properties through the arranging of the molecular structure of the metal. (Handout No. 1)

A. Metals that can be heat treated include steel, iron, aluminum, magnesium, copper, and titanium.

B. A pyrometer is used to measure the high temperatures needed in the heat treatment of metals.

C. When steel is heated, it changes colors; different colors indicate different temperatures.

D. Four basic processes are used in heat treatment of metals: annealing, hardening, tempering, and case hardening.
   1. Annealing is the softening of metal so it can be machined, or shaped.
      a. In annealing, the metal is heated slowly and cooled slowly.
      b. For annealing, heat the metal to a cherry red in color.
      c. Insulating material for annealing includes ashes and vermiculite.
   2. Steel is hardened by heating it to a specified temperature and then cooling it quickly in oil, water, or brine.
      a. To enhance the hardening process, consult a machinist's handbook for the exact temperature for the specified metal, and use a pyrometer during the process.
      b. When quenching, do not drop the metal in; this causes cracks.
      c. A simple test for hardness is to try and file the metal; it cannot be filed if properly hardened.
      d. The degree of hardness that can be produced depends upon three factors: (1) carbon content of the steel, (2) the temperature to which it is heated, and (3) cooling time.
   3. Tempering removes some of the hardness and brittleness, but increases the toughness of steel.
      a. Tempering should be done immediately after hardening so stress cracks do not develop.
      b. Polish the metal to be tempered with abrasive cloth.
      c. The first step is to heat the metal to the correct temperature.
      d. You can tell when the proper temperature is reached by watching the color produced on the piece of metal as it is heated.
      e. When the proper temperature is reached, quench immediately in oil, water, or brine.
      f. When quenching, the product should be rapidly moved about in the solution—up and down, as well as in a circular or figure-eight motion.
      g. Tempering is sometimes referred to as drawing.
   4. Case hardening is the application of a hard outer surface to a soft (low-carbon) steel.
      a. Case hardening can be accomplished by heating the soft metal to a bright cherry red color, removing it from the furnace, moving it around in a case-hardening compound, reheating it, and quenching it.
      b. The longer the soft metal is heated, the greater the depth of the case hardening.

E. The typical procedure is to (a) anneal the metal so it can be worked, (b) harden the metal after it is in its finished shape, and (c) temper the metal to its correct hardness.

F. A furnace or a forge can be used for heat treatment.
   1. The electric heat treatment furnace is popular because it is quiet, does not require any venting, heats rapidly, and has excellent temperature control.
   2. Any piece of metal removed from the forge and left out to cool **MUST** be marked "hot" with chalk.

G. In addition to the goggles and face shield, it is a good idea to wear leather gloves, heavy shoes, and an apron while heat treating metals.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)
- 3 x 5 cards
- Drawing paper, pens, pencils
- Hardness tester
- Various hand tools
- Specimens of various metals (some annealed; some annealed and hardened; some annealed, hardened, and tempered)
- Microscope
- Springs
- Matches
- Paper
- Tongs
- Old file
- Three pieces of the same metal (one annealed; one annealed and hardened; one annealed, hardened, and tempered)

SUGGESTED STUDENT ACTIVITIES

1. Place a photograph of an automobile in the center of a bulletin board. Ask the students to research the parts of the car made by forging. Write the name of the part on a 3 x 5 card, and attach to the bulletin board in a circle around the photograph.
2. Prepare posters on forging safety.
3. Obtain examples of products that have been forged.
4. Ask students to research the early history of forging and report the findings to the class.
5. Use a hardness tester to test the hardness of various tools in several areas of each tool.
6. Prepare specimens of several different metals—some annealed; some annealed and hardened; some annealed, hardened, and tempered. Ask students to view the specimens under the microscope and make drawings of what they see.
7. Ask students to harden a spring and then drop onto a concrete floor.
8. Give each student an old file and three pieces of the same metal: one annealed; one annealed and hardened; one annealed, hardened, and tempered. Ask them to file each piece in a vise and record the results of their efforts on paper. Discuss.

Vocabulary Worksheet

1. forging
2. smithing
3. upsetting
4. drawing
5. drop forging
6. open die forging
7. hydraulic press forging
8. plastic
9. cold heading
10. forge
11. heat treating furnace
12. blacksmith's hammer
13. set hammer
14. swaging hammer
15. forging punches
16. sledge
17. anvil
18. tongs
19. hardy
20. flatter
21. fuller
22. swage
23. pyrometer
24. annealing
25. hardening
26. tempering

27. case hardening

28. vermiculite

29. quenching

30. brine

TEST

UNIT 8: FORGING/HEAT TREATMENT

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Which of the following was forged by early humans?
A. cookingware
B. weapons
C. farming tools
D. all of the above

___ 2. Which of the following is not true?
A. forging produces much less scrap than machining
B. forged parts are stronger than machined parts
C. forging is much more expensive than machining
D. forging improves metal by refining the grain structure

___ 3. A forging operation that increases the thickness of the metal is--
A. swaging
B. upsetting
C. drawing
D. fullering

___ 4. An operation that increases the metal's length, width, or both is--
A. swaging
B. upsetting
C. drawing
D. fullering

___ 5. The most used industrial forging process is--
A. drop forging
B. open die forging
C. hydraulic press forging
D. crank press forging

___ 6. Upset forging cold metal is called--
A. drawing
B. upset forging (it makes no difference if it is hot or cold)
C. cold upset forging
D. cold heading

___ 7. A forging furnace is usually--
A. oil fired
B. gas fired
C. coal fired
D. electrically heated

___ 8. The general-purpose forging hammer is the--
A. hand hammer
B. sledge
C. set hammer
D. swaging hammer

___ 9. The hammer weight recommended for light work is--
A. 1½ to 2½ pounds
B. 2 to 3 pounds
C. 2½ to 3½ pounds
D. 3 to 4 pounds

___ 10. The material from which anvils are made is--
A. wrought iron
B. medium-carbon steel
C. low-carbon steel
D. cast iron

___ 11. Which device is used to hold hot metal while it is being forged?
A. pliers
B. hardy
C. tongs
D. pritchel

___ 12. The softening of metal so it can be machined or shaped is--
A. hardening
B. case hardening
C. annealing
D. tempering

___ 13. An operation that removes some of the hardness and brittleness but increases the toughness is--
A. hardening
B. case hardening
C. annealing
D. tempering

___ 14. Application of a hard outer surface to a soft (low-carbon) steel is done by--
A. hardening
B. case hardening
C. annealing
D. tempering

___ 15. In annealing, the metal is--
A. heated quickly and cooled quickly
B. heated quickly and cooled slowly
C. heated slowly and cooled quickly
D. heated slowly and cooled slowly

___ 16. Tempering is sometimes referred to as--
- A. drawing
- B. upsetting
- C. case hardening
- D. compounding

___ 17. The typical procedure is to--
- A. harden, anneal, temper
- B. anneal, harden, temper
- C. harden, temper, anneal
- D. anneal, temper, harden

HANDOUT NO.1

APPROXIMATE TEMPERATURE INDICATED BY COLORS (STEEL)

COLORS FOR HEATING

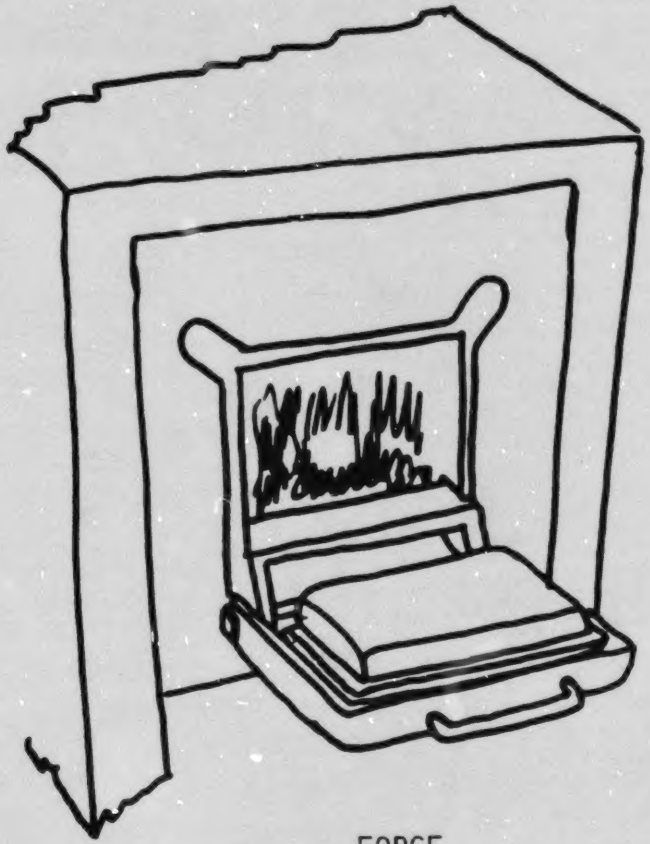
Color	Temperature Range (F)	Uses For Hardening
White	2400-2250	*Hardening of High Speed Steel*
Yellow-White	2250-1850	*Hardening of Alloy Steel*
Yellow	1850-1775	
Orange	1775-1700	
Salmon	1700-1600	*Hardening of Carbon Steel*
Bright Red	1600-1455	
Cherry Red	1455-1310	
Medium Cherry	1310-1210	
Dark Red	1210-1110	
Blood Red	1110-975	
Faint Red	975-760	

COLORS FOR TEMPERING

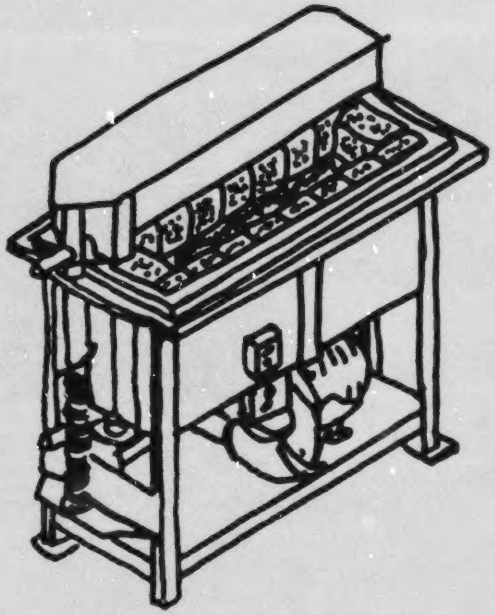
Color	Temperature Range (F)	Appropriate Tools
Pale Blue	760-595	Springs, Wood Saws
Blue	595-560	Wrenches, Chisels
Violet	560-545	
Purple	545-530	Screwdriver Tips
Brown-Purple	530-510	
Brown	510-495	Cold Chisels, Hammer Faces, Wood Chisels
Yellow-Brown	495-485	
Dark Straw	485-475	Punches, Knives
Straw	475-460	
Light Straw	460-440	Drills, Taps, Milling Cutters
Yellow	440-375	Scribers, Hammer Heads, Lathe Centers, Lathe Tools

MW8-1

METHODS OF HEATING METAL



FORGE

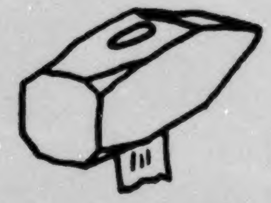


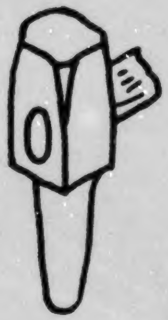
HEAT TREATING FURNACE

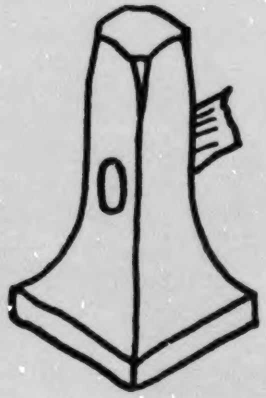
LIGHTING THE FORGE

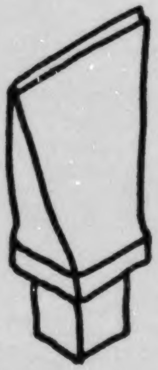
1. OPEN THE FORGE LID
2. MAKE SURE THE GAS JET IS CLOSED
3. INSERT PAPER & LIGHT WITH MATCH
4. OPEN GAS JET
5. TURN ON BLOWER
6. ADJUST GAS JET

ANVIL TOOLS

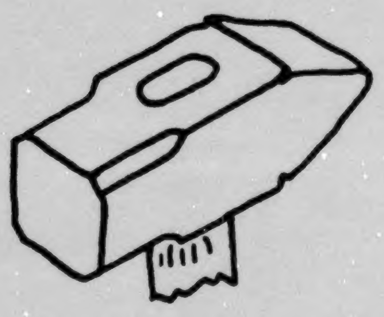

BLACKSMITH'S HAMMER

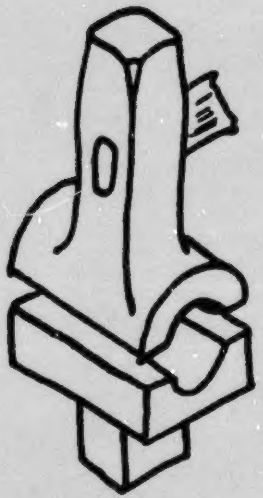

PUNCH

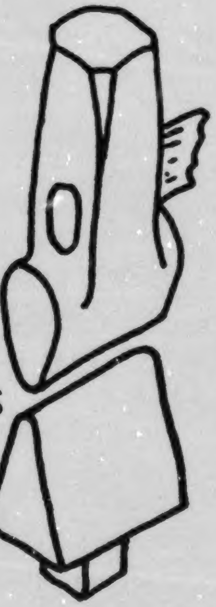

FLATTER


HARDY

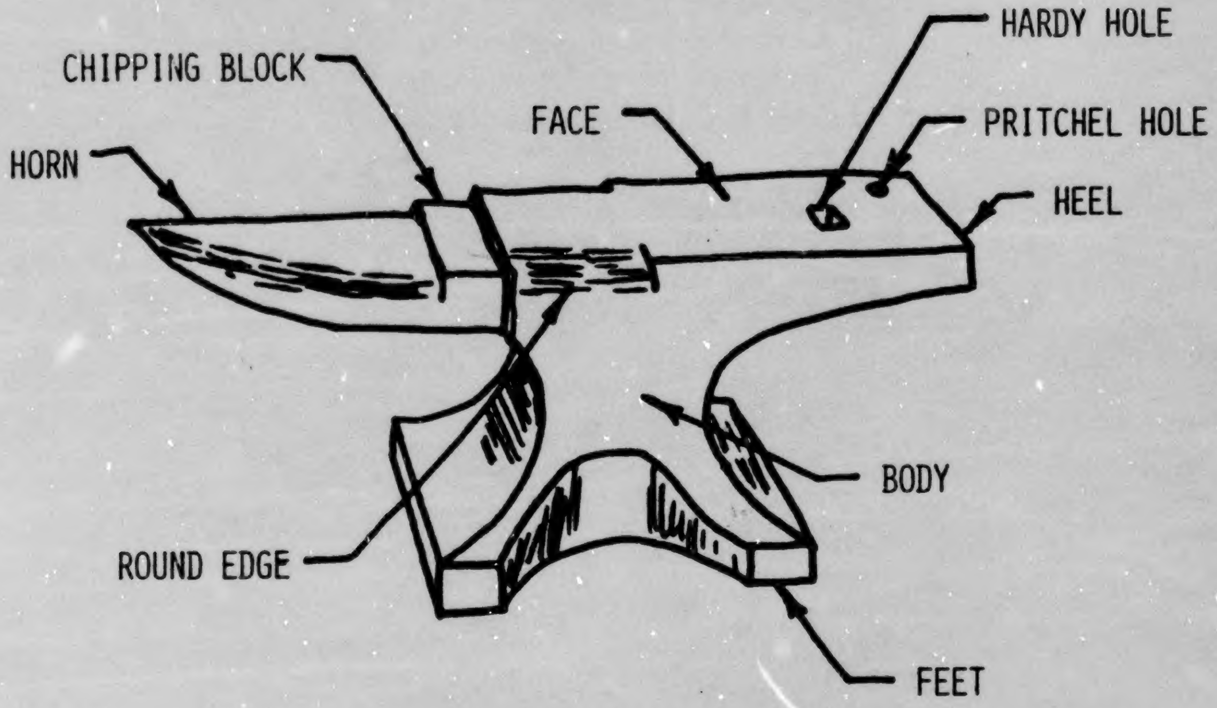
MW8-3


SLEDGE


SWAGES


FULLERS

PARTS OF THE ANVIL


HARDY HOLE
CHIPPING BLOCK
FACE
PRITCHEL HOLE
HORN
HEEL
BODY
ROUND EDGE
FEET

9

Decorative Work

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. list several examples of ornamental metal work;
2. explain the tension/compression phenomenon that occurs during the bending of metal;
3. correctly form metal for ornamental products;
4. determine the amount of metal to be added to the total length in order to compensate for various bends;
5. determine the bending sequence in a workpiece that has several bends;
6. correctly use a bending jig;
7. correctly use a universal bending machine;
8. polish metal using abrasives and a buffer;
9. explain the difference between natural and artificial abrasives;
10. select the correct buffing compound and the correct wheel for a given metal for both coarse and finish buffing;
11. clean metal with both mechanical and solvent cleaning methods;
12. coat metal with paint including an antique finish;
13. coat metal with another metal;
14. explain anodizing;
15. produce an oxide finish on metal;
16. produce an oil finish on steel;
17. produce a satin finish on aluminum;
18. spot finish metal;
19. produce a powder finish; and
20. correctly peen ornamental metal.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

blacksmith
peening
rod parter
scroll
obtuse angle
bending jig
universal bending machine
polishing
abrasive
garnet
flint
crocus
diamond
emery
corundum
aluminum oxide

silicon carbide
boron carbide
buffing
tripoli
rouge
cotton muslin
cotton flannel
wire brush
solvent
toxic
mineral spirits
pickling
scales
alkaline
paint
enamel

lacquer
epoxy
antique finish
spray gun
nozzle
primer coat
red lead
zinc chromate
plating
electroplating
anodizing
oxide finishing
bluing
satin finish
spot finishing
powder finish

TEACHING AIDS

- Overhead projector
- Test Key: 1-B, 2-A, 3-B, 4-D, 5-B, 6-D, 7-D, 8-C, 9-A, 10-B, 11-D, 12-A, 13-C, 14-A, 15-B, 16-D, 17-A, 18-D, 19-B, 20-A.
- Transparencies and Handouts: You will find transparencies MW9-1 through MW9-8 and handouts at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW9-1: Designs
MW9-2: Metal Forming in a Vise
MW9-3: A Bending Jig
MW9-4: Another Type of Bending Jig
MW9-5: Di-Acro Universal Bending Machine
MW9-6: How to Hand Polish
MW9-7: Buffing Compounds
MW9-8: Electroplating

Handout No. 1: Grit Numbers

Student Laboratory Experiment No. 1: Chemical Coloring of Brass
Student Laboratory Experiment No. 2: Chemical Coloring of Copper

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SENTENCE OUTLINE

I. Ornamental metal work
  A. History
    1. In colonial America, the blacksmith produced ornamental metal work using wrought iron.

   2. Ornamental iron originally was wrought iron, but is now a mild steel.
B. Soft steel (low carbon) can be formed to produce ornamental as well as functional products. (Transparency MW9-1)
   1. Ornamental metal work includes consumer products such as fences, patio furniture, gates, railings, stairs, and spiral staircases.
   2. Forming steel includes bending, twisting, beating, peening, and hammering.
   3. Ends of ornamental metal products are sometimes flared.
C. When a piece of metal is bent, the metal on the outside of the bend is in tension, while the metal on the inside of the bend is in compression.
   1. The section of the workpiece that is bent cold becomes harder and stiffer.
   2. If the metal is heated before bending, the bent section does not become harder and tougher due to bending.
      a. Metal is much easier to bend if it is heated.
      b. The common division of whether metal should be bent hot or cold is 1/4" thickness.
D. Preparation
   1. While low-carbon metal rods can be cut to length with a saw, time can be saved if a rod parter is used.
   2. Add an amount of one-half the thickness of the metal to the required length for each bend to be made.
   3. If there are several bends in one piece of metal, the bending sequence must be considered carefully.
   4. Before beginning any complicated bend, such as a scroll, make a full-size pattern on a piece of paper. This is used to check the accuracy of the bend.
E. Hand bending is not an industrial process except on rare occasions such as in the construction of a prototype.
   1. Most angular bends can be made using a vise and a machinist's hammer.
      a. Bending can be done by holding the metal in a vise and striking with a hammer.
      b. A vise and a monkey wrench can be used for making obtuse angle bends. (Transparency MW9-2)
   2. A machinist's vise and a wrench are used to twist mild steel.
      a. If the twist is to be a short section, extend the metal vertically from the vise jaws, use a monkey wrench, and slowly twist the metal.
      b. If the twist is to be a long section, enclose the metal to be twisted in a metal pipe. This will make the twist stay straight.
   3. Curves can be formed on the horn of the anvil, by using a jig, or by forming the metal around other objects.
      a. Bending jigs are in common use for producing scrolls. (Transparencies MW9-3 and MW9-4)
      b. Pieces of pipe and rod can be used with the vise and machinist's hammer in the forming of circular bends.
F. Universal bending machines are designed to cold form rod, bar, strip, angle, and tube into complex shapes. (Transparency MW9-5)
   1. Universal benders use various dies, forms, and clamps with a bending arm to bend various shapes.
   2. A bending machine can make bends exactly alike.
   3. Two common universal benders are the Hossfeld and the Di-Acro.
   4. Industrial bending machines are mostly automatic.
   5. Large machines capable of bending cold metal that is 5 inches thick are common in industry.

II. Finishing
A. Most manufactured products require some kind of finishing: polishing, buffing, cleaning, coating, plating, anodizing, oxidizing, etc.

1. Polishing is the making of smooth metal surface. (Transparency MW9-6)
    a. Polishing is the removing of all tool or cutting marks.
    b. Polishing is the use of successively finer abrasives. (Handout No. 1)
        (1) An abrasive is a hard, sharp, crystalline grain.
        (2) Abrasives may be natural or artificial
            (a) Natural abrasives include garnet, flint, crocus, diamond, emery, and corundum.
            (b) Artificial abrasives include aluminum oxide, silicon carbide, and boron carbide.
            (c) Artificial abrasives are harder, have greater impact toughness, have faster cutting characteristics, retain their cutting properties longer, have uniform quality, and are economical to manufacture in a wider range of grain sizes.
        (3) The abrasives used on most metals are aluminum oxide and silicon carbide.
        (4) Coated abrasives are produced by bonding a particular type and quantity of abrasive grains on a suitable flexible backing material.
        (5) Coated abrasives forms include belts, discs, cloth sheet, and cloth roll.
2. If a shiny finished surface is desired, then buffing is done after the polishing is completed. (Transparency MW9-7)
    a. Buffing compounds are various cutting materials mixed with a heavy grease such as tallow and pressed into bars or cakes.
        (1) Tripoli is the general all-purpose abrasive.
        (2) A fine grade of rouge is generally used on a soft buffing wheel to produce the final luster.
    b. Buffing wheels are made from cloth, felt, or leather.
        (1) A hard, coarse buffing wheel with an appropriate buffing compound is used first.
        (2) Leather and felt wheels are hard and are used for coarse buffing.
        (3) Cloth wheels are made of cotton muslin (hard wheels) and cotton flannel (soft wheels).
    c. Procedure
        (1) Buffing compound is applied by holding it against the revolving wheel.
        (2) Clamp small parts into a holder before buffing.
        (3) Hold the workpiece lightly against the revolving buffing wheel.
        (4) Hold the workpiece on the underside of the front of the wheel.
        (5) The workpiece should be moved and turned as it is held against the buffing wheel.
        (6) The workpiece should be buffed from the center outward to the edges.
        (7) If the workpiece comes from the buffing wheel looking greasy and dirty, too much compound is on the wheel.
3. A metal surface must first be cleaned before it can be finished, because most finishes will not "stick" to unclean surfaces.
    a. Mechanical cleaning includes the use of abrasives and/or wire brushes.
        (1) A wire brush can remove loose scale.
        (2) A wire brush can be a hand-held brush or a wire wheel mounted on a machine.
    b. Solvent cleaning is the use of naphtha, kerosene, or other commercial cleaning fluids.
        (1) The type of solvent used should be carefully selected.
            (a) Most solvents are highly flammable.
            (b) Some solvents are toxic.
            (c) Use mineral spirits as a solvent for cleaning metal surfaces.
        (2) Pickling is the use of acid to remove oxides, scales, or stains.

    (3) Metals can be cleaned by soaking and flushing in detergent and/or alkaline solutions.
        (a) Alkaline solutions can be used full strength on ferrous metals.
        (b) Weak alkaline solutions should be used on nonferrous metals.
    (4) Use lacquer thinner to degrease surfaces which are to be lacquered.
    (5) Do not handle degreased, cleaned surfaces with bare hands.

4. Coating is the layering of a material over a metal surface.
    a. A finish coats the surface of metal and protects the surface from rusting.
    b. Most coatings are liquid when applied, and air-dry within one to eight hours.
    c. Coatings include oxides, paint, enamel, lacquer, resin-base, and epoxy-base finishes.
        (1) To keep the original color of metal, coat with lacquer.
        (2) Flat lacquer has no shine.
        (3) Lacquer is harder and tougher than enamel.
        (4) An antique finish can be produced on peened metal by heating or painting the metal, then polishing the high surfaces, and finally coating it with a clear lacquer.
        (5) Flat, black paint is usually used as a finish for ornamental work.
    d. Coatings are normally very thin and are applied by brushing, dipping, or spraying.
        (1) If at all possible, do not use a brush.
        (2) The surface to be sprayed should be in a vertical position.
            (a) The nozzle of the spray gun should be kept at a constant distance from the workpiece.
            (b) Spraying strokes should run the entire length of the surface to be finished.
            (c) Small jobs can be done with aerosol cans.
        (3) Clean all equipment immediately after use.
        (4) Automated industrial finishing systems use dipping and/or spraying.
    e. If more than one layer of coating is used, the first layer is called the primer coat and the last layer is called the finish coat.
        (1) Red lead is a good primer for ferrous metal surfaces to be coated.
        (2) Galvanized steel, which is to be painted, should be prime-coated with a zinc chromate primer.
        (3) Several thin coats always produce a better finish than one thick coat.
        (4) Light sanding is done between layers to remove any slight high spots.

5. Coating metal with another metal is called plating.
    a. All common metals can be plated.
    b. Common plating metals include gold, silver, zinc, tin, copper, nickel, and chrome.
        (1) Galvanizing is plating steel with zinc.
        (2) Steel is plated with tin for food containers.
    c. Hot dipping produces a thicker plate and is relatively inexpensive.
    d. Electroplating produces a smooth, thin plate—but is more expensive. (Transparency MW9-8)
        (1) In electroplating, the cathode (product) is submerged in a liquid (electrolyte) and connected to the negative terminal of a DC power supply. The anode (plating metal) is also submerged and is connected to the positive terminal. The anode dissolves and collects on the cathode.
        (2) While the plating of a car bumper is usually 0.030" thick, most plating is only 0.003" to 0.005".

6. Anodizing is a protective electrochemical finish applied to aluminum and magnesium.
    a. Aluminum is anodized in a sulfuric acid solution.
    b. Magnesium uses a dichromate solution for anodizing.
    c. Colored dyes are used in the anodizing process to produce a color coat that cannot be scratched or rubbed off.
7. Oxide finishing causes oxygen to combine with the metal to form a thin layer of colored metallic oxide.
    a. An oxide finish can be easily produced on copper in a variety of colors.
    b. The color produced by the oxide finish process depends upon the time the workpiece is left in the solution.
    c. Bluing is an oxide coating that is usually produced on firearms.
    d. Oxide finishes must be protected with a coat of clear lacquer.
8. An oil finish can be produced by polishing the metal to a high luster, heating it, and quenching it in oil.
9. A satin finish can be produced on aluminum by wire brushing.
10. An ornamental finish called spot finishing can be produced on flat surfaces by placing a short piece of wooden dowel in a drill press chuck, coating the surface with oil and abrasive flour, setting the drill press on its highest RPM, and lightly pressing the end of the dowel against the surface.
11. A powder finish can be applied by cleaning the surface, painting with clear or color lacquer, and—while the lacquer is still sticky—blowing a selected color powder onto the surface.
12. Penning is a decorative process that involves covering the surface with a series of indentations produced by the continuous striking of the surface with the ball end of a machinist's hammer.

B. Some metals rust or corrode if they are not finished.
C. Finishing increases the value of an object.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)
- ¼" square mild steel bar, 8" long
- Bench vise
- Machinist's hammer
- ½" x 6" strips (4 each) of brass, copper, aluminum, steel, iron
- Detergent
- Lacquer thinner
- Colored enamel
- Colored lacquer
- Small pieces (@ 36 sq. in. each) of cast iron, aluminum, brass, copper, tool steel
- Examples of various material and artificial abrasives—all the same grade value
- Tripoli
- Rouge
- Container to hold 12 oz.
- 1-gallon jug
- Household ammonia
- Sal ammoniac
- Salt
- Water
- Ammonium sulfide or potassium sulfide

SUGGESTED STUDENT ACTIVITIES

1. Make a list of products that are used every day that are made by metal forming.
2. Make a collection of illustrations and photographs showing various ornamental metal products.
3. Discuss the properties of low-carbon steel.
4. Ask students to bend a ¼" square bar to a right angle. They are to look closely at the inside and outside of the bend and write down and/or draw what they see.
5. Research the dangers of structural iron work.
6. Research the steps necessary to finish an automobile body.
7. Make a list of items that are plated—base metal as well as plating.
8. Make a list of items that are coated—base metal as well as coating.
9. Give each student several small strips of various metals. Ask students to clean the strips with different cleaning solutions (water, detergent, lacquer thinner, etc.) and record what solution was used on each metal. Immediately coat all strips with the same coating (enamel, lacquer). After 24 hours, ask the students to check the quality of the coatings and record their impressions.
10. Research how emery cloth is made. Draw a diagram that explains the step-by-step process.
11. Develop a display of examples of various natural and artificial abrasives in different forms.
12. Give each student various abrasives of the same grade value, and samples of various kinds of metal (cast iron, aluminum, brass, copper, and tool steel). Each student is to spend the same amount of time using each abrasive on each metal sample; then rank each abrasive from best to worst for each metal.
13. Polish and buff small strips of various metals (iron, steel, aluminum, brass, copper); let stand for one week; then write a short report on how air affects the various metals.
14. Make a brief report to the class on the uses of tripoli and rouge by early civilizations.
15. Have students chemically color brass (see Student Laboratory Experiment No. 1).
16. Have students chemically color copper (see Student Laboratory Experiment No. 2).

Vocabulary Worksheet

1. blacksmith
2. peening
3. rod parter
4. scroll
5. obtuse angle
6. bending jig
7. universal bending machine
8. polishing
9. abrasive
10. garnet
11. flint
12. crocus
13. diamond
14. emery
15. corundum
16. aluminum oxide
17. silicon carbide
18. boron carbide
19. buffing
20. tripoli
21. rouge
22. cotton muslin
23. cotton flannel
24. wire brush
25. solvent

26. toxic
27. mineral spirits
28. pickling
29. scales
30. alkaline
31. paint
32. enamel
33. lacquer
34. epoxy
35. antique finish
36. spray gun
37. nozzle
38. primer coat
39. red lead
40. zinc chromate
41. plating
42. electroplating
43. anodizing
44. oxide finishing
45. bluing
46. satin finish
47. spot finishing
48. powder finish

TEST

UNIT 9: DECORATIVE METAL

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Ornamental metal work is generally made from--
A. wrought iron
B. low-carbon steel
C. medium-carbon steel
D. high-carbon steel

___ 2. When a piece of metal is bent--
A. the metal on the outside of the bend is in tension while the metal on the inside of the bend is in compression
B. the bend creates tension
C. the metal on the outside of the bend is in compression while the metal on the inside of the bend is in tension
D. the bend creates compression

___ 3. The common division of whether the metal should be bent hot or cold is--
A. 1/8"
B. 1/4"
C. 3/8"
D. 1/2"

___ 4. To cut 1/4" diameter low-carbon steel rod to length, you should use--
A. hand hacksaw
B. side cutting pliers
C. vertical band saw
D. rod parter

___ 5. How much metal should be added to the total length of the metal piece for each bend to be made in that piece?
A. 1/4 the thickness of the metal for each bend
B. 1/2 the thickness of the metal for each bend
C. the thickness of the metal for each bend
D. two times the thickness of the metal for each bend

___ 6. An obtuse angle is--
A. 45^o
B. less than 80^o
C. 90^o
D. greater than 90^o

___ 7. Which of the following are finishing processes?
A. polishing
B. cleaning
C. plating
D. all of the above

___ 8. Which of the following is not a natural abrasive?
A. garnet
B. crocus
C. boron carbide
D. emery

___ 9. Which of the following is a general, all-purpose buffing compound?
A. tripoli
B. rouge
C. lime
D. crocus

___ 10. Which of the following is a soft buffing wheel?
A. felt
B. cotton flannel
C. leather
D. cotton muslin

___ 11. Which of the following statements is incorrect?
A. Hold the workpiece lightly against the revolving buffing wheel.
B. Hold the workpiece on the underside of the front of the wheel.
C. The workpiece should be moved and turned as it is held against the wheel.
D. The workpiece should be buffed from the edges toward the center.

___ 12. Pickling is a solvent cleaning process that uses--
A. acid
B. mineral spirits
C. lacquer thinner
D. alkaline

___ 13. Which of the following is not a coating for metal?
A. oxide
B. enamel
C. alkaline
D. lacquer

___ 14. Which of the following finishes is usually used for ornamental metal work?
A. flat, black paint
B. red lead
C. zinc chromate
D. clear lacquer

___ 15. A good primer for ferrous metal surfaces which are to be coated is--
A. flat, black paint
B. red lead
C. zinc chromate
D. clear lacquer

___ 16. Which of the following is not a common plating metal?
A. gold
B. nickel
C. zinc
D. steel

___ 17. A protective electrochemical finish applied to aluminum and magnesium is--
A. anodizing
B. electroplating
C. hot dipping
D. galvanizing

___ 18. Which finish is produced on aluminum by wire brushing?
A. powder finish
B. spot finish
C. oxide finish
D. satin finish

___ 19. Which finish is produced on flat surfaces by placing a short piece of wooden dowel in a drill press chuck and coating the surface with oil and abrasive flour?
A. powder finish
B. spot finish
C. oxide finish
D. satin finish

___ 20. Which finish is produced by blowing color particles on a sticky, clear lacquer finish?
A. powder finish
B. spot finish
C. oxide finish
D. satin finish

HANDOUT NO. 1

GRIT NUMBERS

	Very Coarse	Coarse	Medium	Fine	Very Fine	Super Fine
Aluminum Oxide Silicon Carbide	12 16 20 24 30	36 40	50 60 80 100	120 150 180	220 240 280 320 360	400 500 600
Emery		3 2½	2 1½ 1 ½	0 2/0 3/0		

STUDENT LABORATORY EXPERIMENT NO. 1

Chemical Coloring of Brass

Materials

1 brass strip, 1 x 6, any gauge
1 container to hold 12 ounces
1 jug, 1-gallon size
4 oz. ammonia, household
2 oz. Sal ammoniac
2 oz. salt
1 gallon water

Procedure

1. Fill a 1-gallon jug to within 3 inches of the top with clean, warm water.
2. Add 2 ounces of table salt. Shake until the salt is dissolved.
3. Add 2 ounces of Sal ammoniac. Stir well.
4. Add 4 ounces of ammonia. Shake.
5. Pour about 12 ounces of the solution into a glass, or similar container.
6. Place a cleaned brass strip in the solution.
7. Remove the strip every 5 minutes for 30 minutes; record the results.

5 minutes - ____________________

10 minutes - ____________________

15 minutes - ____________________

20 minutes - ____________________

25 minutes - ____________________

30 minutes - ____________________

STUDENT LABORATORY EXPERIMENT NO. 2

Chemical Coloring of Copper

Materials

1 copper strip, 1 x 6, any gauge
1 container to hold 12 ounces
1 jug, 1-gallon size
1 gallon water, cold
1 oz. ammonium sulfide or potassium sulfide

Procedure

1. Fill a 1-gallon jug to within 3 inches of the top with clean, cold water.
2. Add 1 ounce of ammonium sulfide or potassium sulfide.
3. Pour about 12 ounces of the solution into a glass or similar container.
4. Place the copper strip (cleaned) in the solution.
5. Return the copper strip to the solution for another 20 minutes. What change (changes) has (have) occurred?

____

____

____

6. Remove the strip every 5 minutes for 30 minutes; record the results.

5 minutes - ____

10 minutes - ____

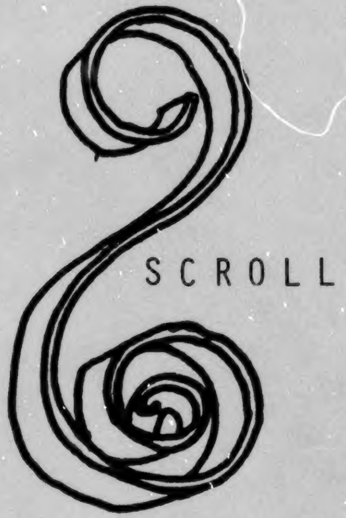
15 minutes - ____

20 minutes - ____

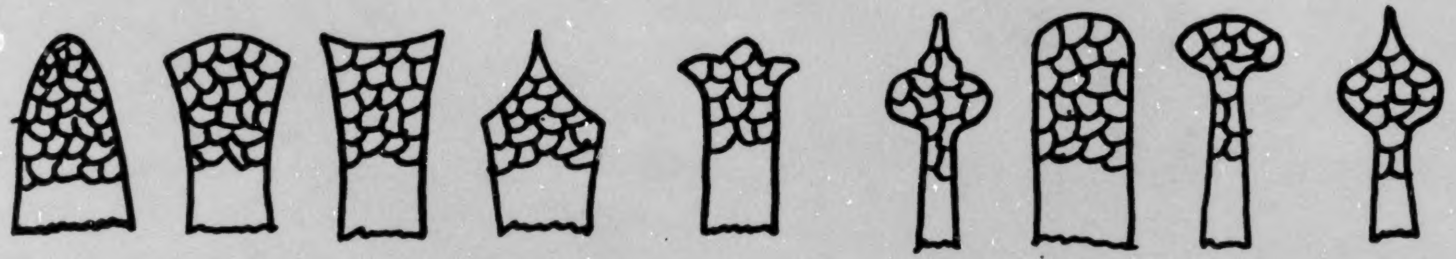
25 minutes - ____

30 minutes - ____

DESIGNS

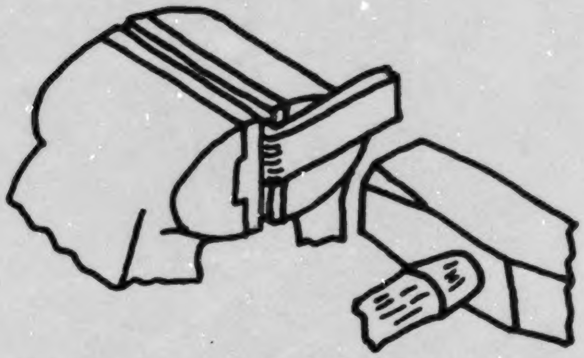


MW9-1



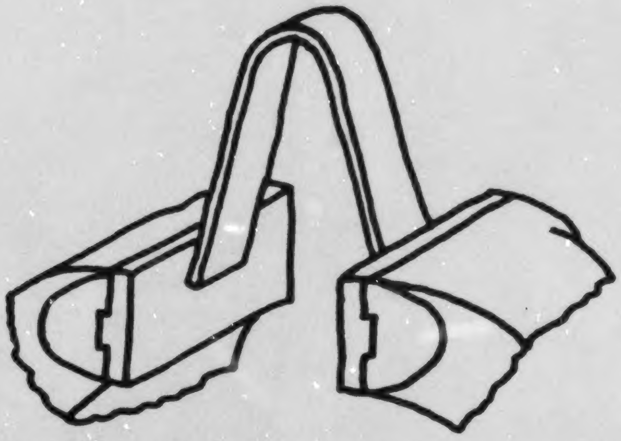
VARIOUS SHAPES FOR ENDS OF METAL

METAL FORMING IN A VISE

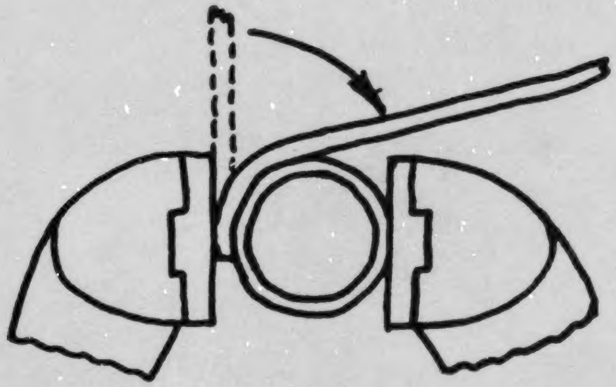


MAKING A RIGHT ANGLE BEND

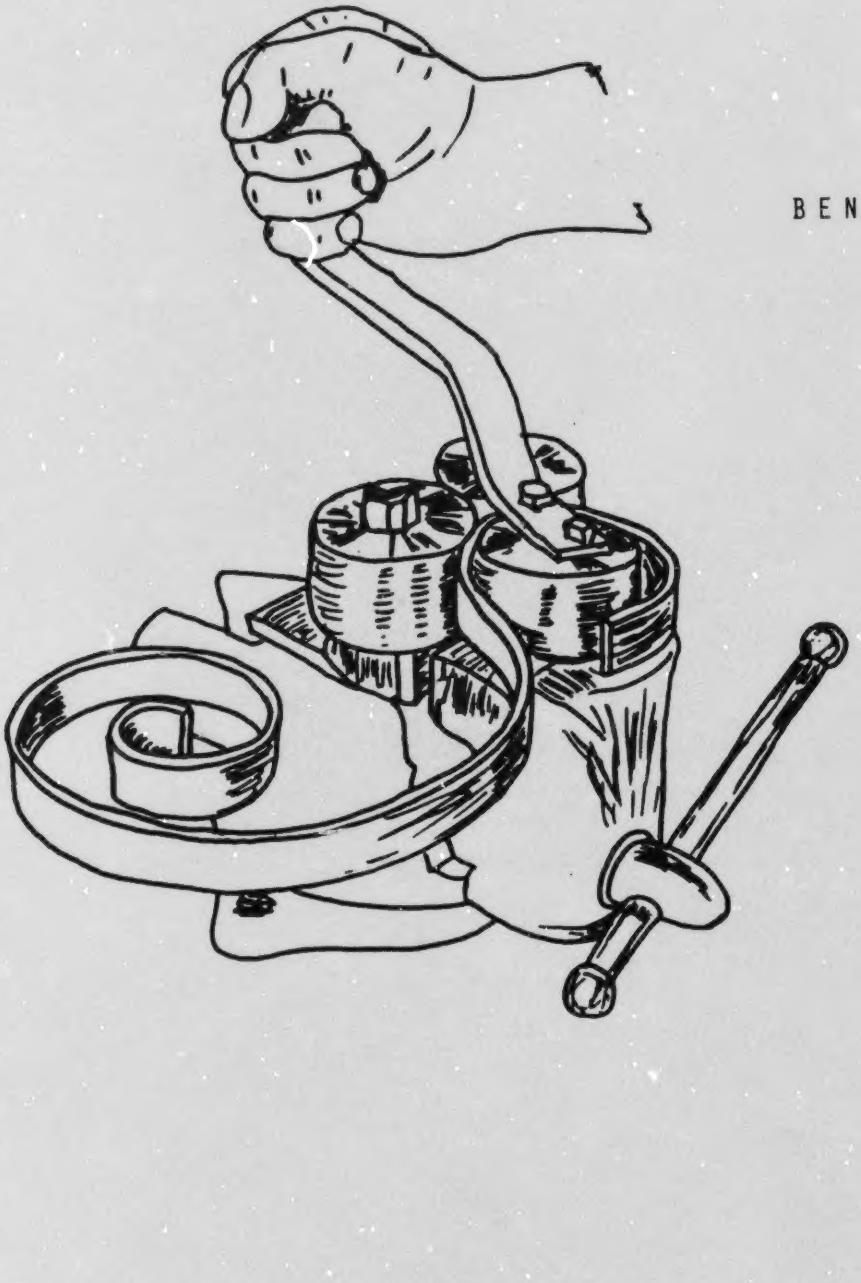
MW9-2



MAKING AN ACUTE ANGLE BEND



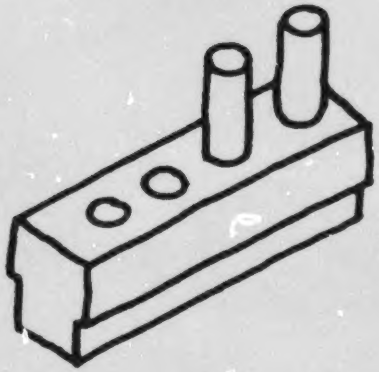
FORMING A CURVED SECTION



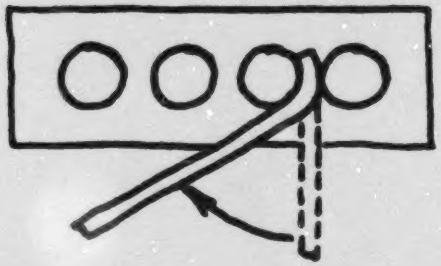
A
BENDING
JIG

MW9-4

ANOTHER TYPE OF BENDING JIG



MAKING A SCROLL ON THIS BENDING JIG



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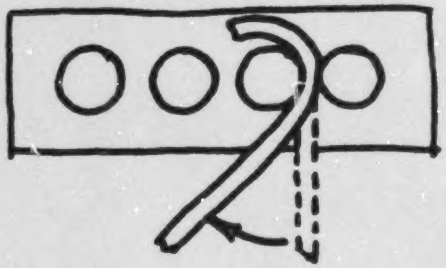

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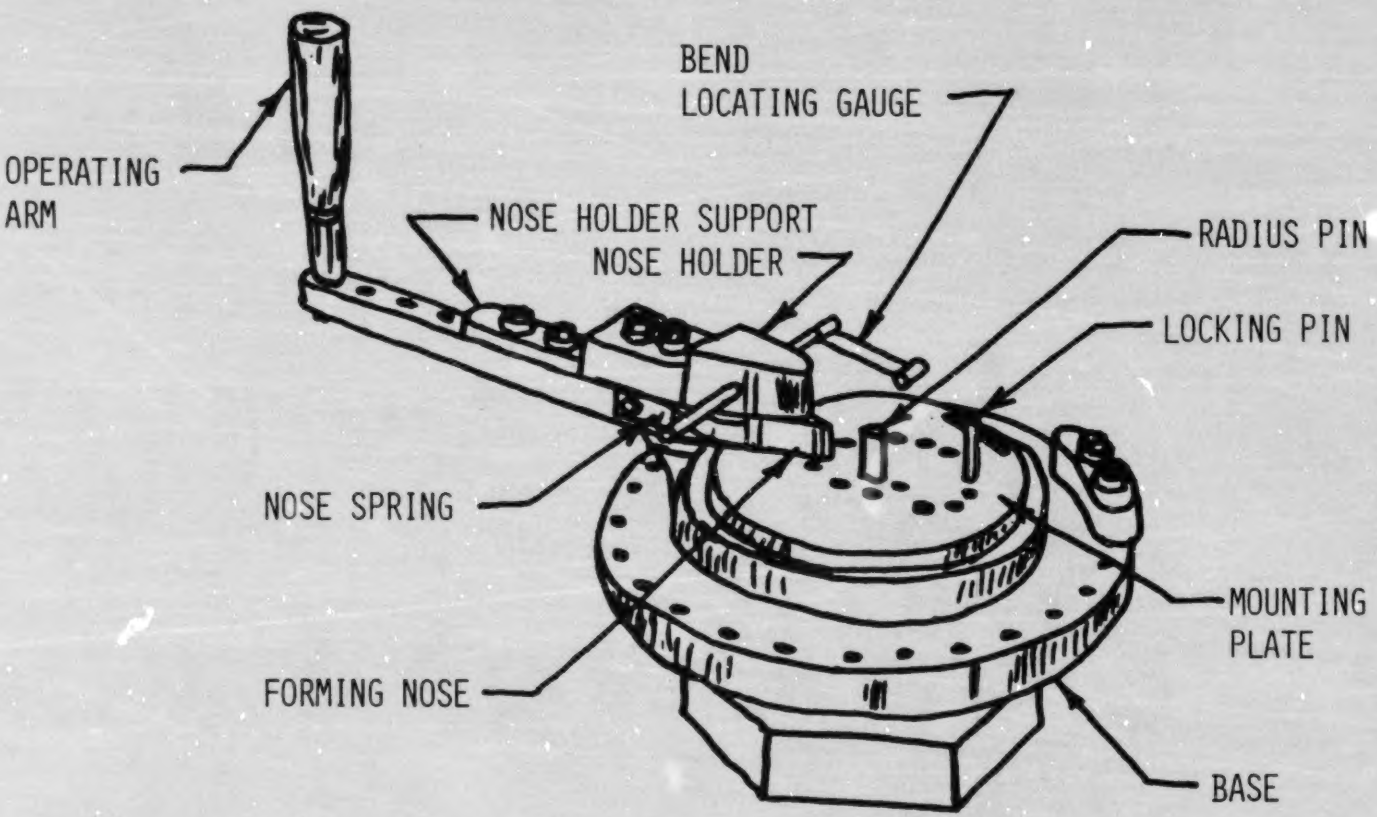
DI-ACRO UNIVERSAL BENDING MACHINE

MW9-5


BEND
LOCATING GAUGE
OPERATING
ARM
NOSE HOLDER SUPPORT
NOSE HOLDER
RADIUS PIN
LOCKING PIN
NOSE SPRING
MOUNTING
PLATE
FORMING NOSE
BASE

HOW TO HAND POLISH

1. SELECT THE COARSEST GRADE POSSIBLE
2. TEAR A STRIP SLIGHTLY WIDER THAN THE WIDTH OF THE BACKING OBJECT
3. GRIP THE WORKPIECE SECURELY IN A HOLDING DEVICE
4. APPLYING SLIGHT DOWNWARD PRESSURE, MOVE THE ABRASIVE IN A STRAIGHT LINE OVER THE WORKPIECE
5. TAKE AS LONG AS STROKE AS POSSIBLE
6. CUT ON BOTH THE FORWARD AND RETURN STROKES
7. CHANGE TO A FINER GRADE AND REPEAT THE PROCEDURE
8. CHANGE TO THE FINEST GRADE AND REPEAT THE PROCEDURE

BUFFING COMPOUNDS

METAL	COMPOUND	
	ROUGHING	FINISHING
ALUMINUM	TRIPOLI	ROUGE
BRASS	TRIPOLI	LIME
COPPER	TRIPOLI	LIME
PEWTER	TRIPOLI	ROUGE
STEEL	400 SILICON CARBIDE	ROUGE

ELECTROPLATING

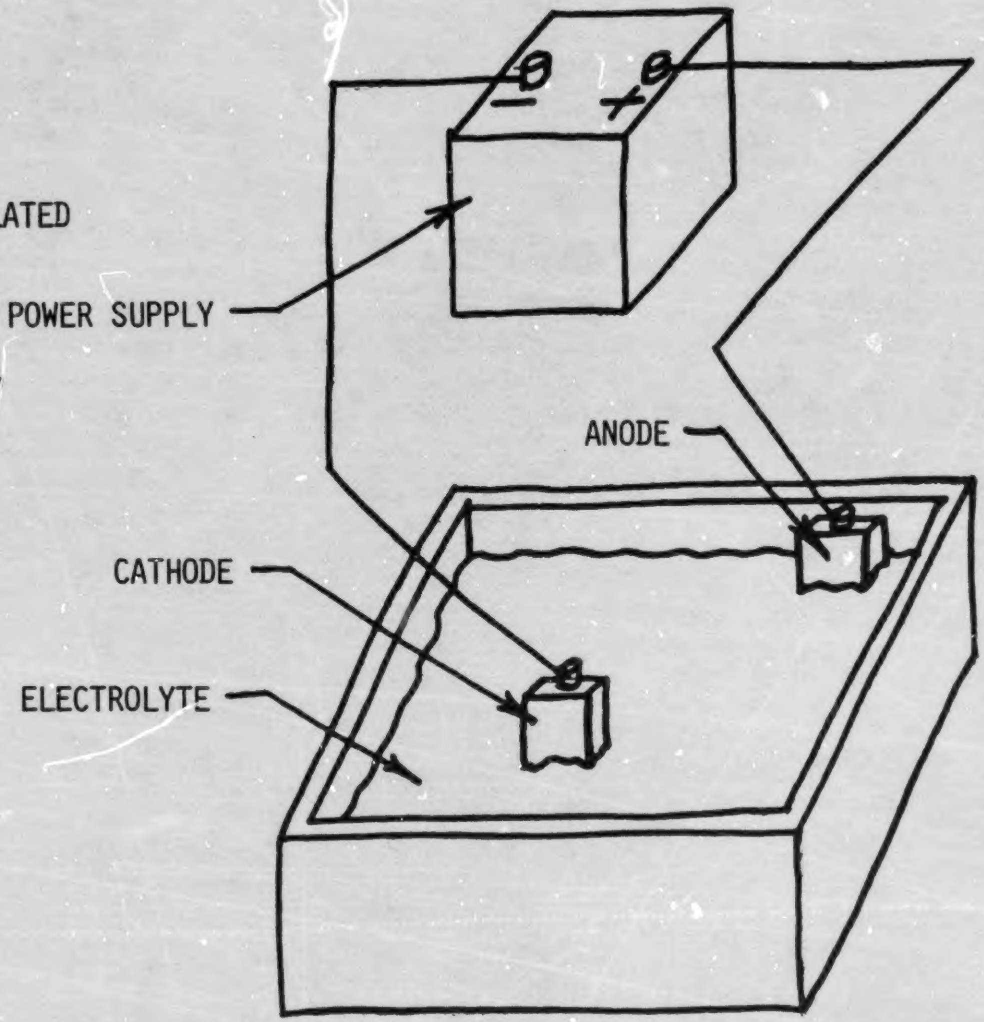
FOR ELECTROPLATING STEEL:

ANODE = COPPER STRIP

CATHODE = STEEL TO BE ELECTROPLATED

ELECTROLYTE = COPPER SULFATE SOLUTION

POWER SUPPLY = TWO 1.5 VOLT DRY CELLS


−
+
POWER SUPPLY
ANODE
CATHODE
ELECTROLYTE

10

Metal Casting

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. discuss the history of metal casting;
2. define the various kinds of foundries;
3. describe destructive casting and investment casting;
4. describe centrifugal casting, die casting, dip molding, and slush molding;
5. describe plaster mold casting;
6. describe shell casting;
7. describe sand casting;
8. explain the operation of a crucible furnace;
9. prepare green sand for casting;
10. list the various foundry tools and equipment, and describe their uses;
11. describe various types of patterns;
12. correctly make a sand casting; and
13. list the various parts of the gating system, and describe the purpose of each.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

Saugus Iron Works
John Wilkenson
sand slinger
jolt squeeze machine
production foundry
jobbing foundry
captive foundry
independent foundry
destructive foundry
investment casting
styrofoam
ceramic slurry
core
parting line
permanent mold casting
centrifugal casting
die casting
dip molding
slush molding
plaster mold casting

shell molding
thermosetting resin
phenolic
CO_2 molding
crucible furnace
pyrometer
tongs
shank
flux
green sand
synthetic sand
flask
cope
drag
bottom board
molding board
parting dust
riddle
bench rammer
strike-off bar

vent wire
sprue pin
sprue cutter
bulb sponge
draw sponge
draw screw
bellows
molder tools
skimmer
simple pattern
split pattern
match plate
shrink rule
draft
gating system
pouring basin
sprue
sprue base
runners
gates
risers

TEACHING AIDS

- Overhead projector
- Test Key: 1-C, 2-A, 3-A, 4-D, 5-C, 6-A, 7-D, 8-B, 9-A, 10-C, 11-D, 12-A, 13-B, 14-D, 15-B, 16-C, 17-A, 18-C, 19-B, 20-A, 21-B, 22-D, 23-C, 24-D, 25-A, 26-B, 27-A, 28-C, 29-B

- Transparencies and Handouts: You will find transparencies MW10-1 through MW10-17 and Handouts No. 1 through No. 3 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW10-1: Metal Casting (with Cores)
MW10-2: Destructive Casting in the School Lab
MW10-3: Investment Casting
MW10-4: Centrifugal Casting Machine
MW10-5: Die Casting
MW10-6: Crucible Furnace
MW10-7: To Light a Crucible Furnace
MW10-8: Crucibles
MW10-9: Melting Temperatures of Metals
MW10-10: Foundry Rules and Regulations
MW10-11: Flask Terminology
MW10-12: Sand Mold
MW10-13: Foundry Tools
MW10-14: Ramming the Drag
MW10-15: Marking for the Gating System
MW10-16: Ramming the Cope
MW10-17: Cutting a Gating System

Handout No. 1: Comparison of Casting Processes
Handout No. 2: Search for Foundry Terms (see page 297 for solution)
Handout No. 3: Causes of Casting Failures (After Pouring)

SUGGESTED REFERENCES

Cowles, F. T. An Elementary Foundry Manual. Danville, Ill.: McEnglevan Heat Treating and Manufacturing Co., 1967.

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Kazanas, H. C., and Hannah, L. Manufacturing Processes: Metals. Englewood Cliffs, N.J.: Prentice-Hall, 1976.

Kozak, M. R. "Production/Manufacturing—Investment Casting," Man, Society, and Technology, Vol. 42, March 1983, p. 25.

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Metalworking. Encino, Calif.: Glencoe Publishing Co., 1978.

Miller, R., and Morrisey, T. J. Metal Technology. Indianapolis, Ind.: Howard W. Sams, 1975.

Miller, W. R., et al. Metalworking. Bloomington, Ill.: McKnight, 1978.

Walker, J. R. Exploring Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.

Walker, J. R. Modern Metalworking. South Holland, Ill.: Goodheart-Willcox, 1976.

SENTENCE OUTLINE

I. A casting is the product of the casting process.
  A. Primitive casting (copper) developed around the Eurasiatic Steppe Belt.
  B. Primitive society's casting needs included weapons, jewelry, and religious items.
  C. The earliest recorded investment casting was in China before 1700 B.C.
  D. Cast crucible steel was developed in India in 500 B.C.
  E. Iron castings were first made by the Chinese in the sixth century B.C.
  F. Investment casting was used in Italy in the 1300s and in South America in the 1500s.
  G. The first iron casting in America was produced in 1642 at the Saugus Iron Works in Massachusetts.
  H. In 1794, John Wilkenson of England invented the first cupola melting furnace.
  I. Shell molding was developed during the late 1940s.

II. The metal casting industry is one of the largest in the United States. (Transparency MW10-1, Handout No. 1)
  A. Sand casting is the most widely used industrial casting technique.
    1. Hand ramming of sand is rarely used today in industry.
    2. In industry, sand is packed into the mold with machines like a sand slinger or a jolt squeeze machine.
  B. Places that cast metal are called foundries.
    1. Production foundries mass-produce one type of casting.
    2. Jobbing foundries incorporate low production rates to produce a variety of castings.
    3. A captive foundry is owned by a large company that uses all or most of the produced castings.
    4. An independent foundry is normally small, privately owned, and produces castings by contract with customers.
  C. While all metals can be cast, only a few are used in industry.
  D. Metal castings vary in weight from a few ounces to several tons.
  E. Destructive casting uses a one-piece mold that is destroyed by the molten metal. (Transparency MW10-2)
    1. Destructive casting uses Styrofoam patterns coated with wax.
      a. Styrofoam can be machined with high speed and low feed.
      b. Styrofoam can be cut with a hot wire.
    2. There is no need for a cope and drag flask.
      a. The flask can be a tin can, a cardboard box, or just a pile of sand.
      b. Once the pattern is buried in the sand, it is not removed.
    3. Do not vent the pattern—it will then burn, not vaporize.
  F. Investment casting has been used for many centuries. (Transparency MW10-3)
    1. The United States used this process during World War II for complex, undercut items with smooth surfaces and close tolerances.
    2. Industrial investment castings have increased over 100% during the last five years.
    3. Investment casting process: (a) A metal pattern mold is made. (b) Wax or polystyrene is used to produce the patterns. (c) Several patterns are attached to a gating system. (d) This cluster is coated—usually by dipping—with a ceramic slurry. (e) This shell mold is heated, and the wax or polystyrene is burned out. (f) The metal is then poured into the shell mold.
      a. Investment casting can be used for ferrous and nonferrous metals.
      b. Investment casting can be used for casting unmachinable alloys and for casting radioactive metals.
      c. Plaster cores are used to produce thin walls.
      d. No parting lines are produced.

4. Most castings are small, but some can weigh as much as 100 pounds.
5. Investment casting is also called the lost wax process.

G. Permanent mold castings are usually nonferrous castings produced in a metal mold that is not destroyed when removing the casting.
1. Centrifugal casting is a form of permanent mold casting. (Transparency MW10-4)
a. Centrifugal casting produces very dense castings.
b. Ferrous and nonferrous metals can be used in centrifugal casting.
c. Centrifugal casting is done by pouring metal into a vertical or horizontal revolving mold.
2. Die casting is a variation of the permanent mold process. (Transparency MW10-5)
a. Die casting provides economical production of large quantities at very high output rates.
b. Die casting machines are among the most complex equipment used in any major casting method.
c. In die casting, the molten metal is forced into a mold under pressure, and pressure is kept until the metal has solidified.
(1) Steel molds are normally used for die casting.
(2) Die casting pressure ranges from 80 to 40,000 psi.
(3) Die casting develops superior finish quality and surface detail.
d. Only nonferrous metals are suitable for die casting.
3. Dip molding is a form of permanent mold casting.
a. Dip molding produces a hollow product that is finished on its interior surface.
b. Dip molding procedure:
(1) The mold is dipped into a container of molten metal.
(2) It is immediately removed.
(3) The metal hardens.
(4) The part is removed from the mold.
4. Slush molding is a form of permanent mold casting.
a. Slush molding produces a hollow casting with a finished exterior surface.
b. Slush molding procedure:
(1) Molten metal is poured into a mold.
(2) Molten metal is allowed to slightly harden.
(3) The remaining molten metal is poured out.
(4) The partially hollow casting is removed from the mold.

H. Plaster mold casting
1. As the name implies, the casting mold is made of plaster.
2. Plaster molds are used only once.
3. Thinner sections can be cast using plaster mold casting rather than sand casting because dried plaster has much less chilling action.

I. Shell molding is a relatively new process.
1. Shell molding is a variation of sand casting.
2. A shell casting is produced with greater accuracy than sand casting.
a. A metal pattern is heated, it is coated with a mixture of sand and a thermosetting resin, cured in an oven, the pattern removed, and the shell halves hardened together.
(1) Shell molds are destroyed after one use.
(2) Phenolic (phenolformaldehyde) is the resin most often used in shell molding.
b. A shell mold casting has a superior surface finish.
3. Shell molding is well adapted for mass production.

J. CO_2 molding is similar to shell molding except it does not use a heated pattern.

III. Sand casting is the most common foundry process used in the school laboratory.
   - A. A simple soldering furnace can be used to melt metals with a lower melting temperature (lead, pewter, zinc).
   - B. A crucible furnace is used to melt aluminum, brass, and some iron.
     - 1. A crucible is used to hold the metal being melted in a crucible furnace. (Transparency MW10-6)
       - a. The metal to be melted is put into a graphite crucible.
       - b. Aluminum is one of the ideal metals for a beginner.
       - c. Do not mix metals in the furnace.
     - 2. Light the furnace and use a pyrometer to check the temperature of the metal. (Transparency MW10-7)
     - 3. Tongs are used to remove the crucible from the crucible furnace.
     - 4. The crucible is placed into a shank for pouring. (Transparency MW10-8)
       - a. After the metal is melted, but before pouring, a flux is added which causes the impurities to rise to the surface. (Transparency MW10-9)
       - b. Stand to one side when pouring molten metal. (Transparency MW10-10)
       - c. Stop pouring when the riser(s) and sprue holes are full.
       - d. Keep loose sand available, when pouring, to cover any molten metal that escapes from the flask (runout). (Transparency MW10-11)
   - C. Shake out the mold only after you are sure the casting is cool.
   - D. Cut off the sprue and riser.
   - E. The major differences between industrial sand casting and that in most school laboratories are size, quantity, and automation.

IV. Good castings require good molding sand. (Handout No. 3)
   - A. Sand was probably the earliest material used for mold making and is still the most widely used material.
   - B. Molding sand is either natural or synthetic.
     - 1. Natural sand is referred to as green sand and requires the use of water as a binder. (Transparency MW10-12)
       - a. Tempering is the process of adding water to green sand so it will pack.
         - (1) If green sand contains too much moisture, the resultant gas or steam can cause defects in the casting.
         - (2) Green sand is a mixture of sand, clay, water, and binders.
       - b. Green sand is mixed in mulling machines.
       - c. "Green" as used in green sand is similar to "green" as used in green lumber: moisture content.
     - 2. Synthetic sand has an oil binder.

V. Tools/Equipment (Transparency MW10-13)
   - A. Flasks are containers or boxes used to hold the molding sand when ramming a mold.
     - 1. The cope is the top half of a flask. (Transparency MW10-14)
     - 2. The drag is the bottom half of the flask.
     - 3. Bottom boards are used to support the flask and mold.
     - 4. A molding board is a flat board on which the pattern is placed.
   - B. Parting dust (powdered silica, brick dust, bone flour, fine charcoal) is sifted over the pattern to prevent sand sticking to the pattern.
   - C. Riddles are used to screen the sand.
   - D. Bench rammers are usually made of hickory or maple and are used to pack the sand into the flask.
   - E. A strike-off bar is used to level the sand in the flask after it has been rammed.
   - F. A vent wire is used to make vent holes after the flask is rammed and leveled off.
   - G. Sprue pins are used to make the vertical passageways.
   - H. Sprue cutters cut the vertical passageways.

- I. A bulb sponge moistens the sand around a pattern before lifting the pattern from the flask.
- J. Draw screws and/or lift pins are used to remove the pattern from the mold.
- K. Bellows are used to blow loose sand from the mold surface.
- L. Molder's tools come in a variety of sizes and shapes and are used for repairing molds and for putting finishing touches on molds.
- M. A skimmer is a ladle with holes and is used to remove slag from the crucible.

VI. The cavity in a sand mold is made from a pattern.

- A. Types of patterns
  1. A simple pattern is a one-piece pattern.
  2. Split patterns are in two or more parts, and are used for complex shape castings.
  3. A match plate is a board (wood or metal) on which the pattern and gating system are split along the parting line and mounted back to back to form a single piece.
- B. A pattern is made slightly larger than the finished casting because the metal shrinks as it cools.
  1. A shrink rule is used in the construction of a pattern.
  2. Different shrink rules are available for different metals.
- C. A pattern normally has draft.
  1. Draft is a slight taper.
  2. Draft permits the pattern to be lifted from the sand without damaging the mold.
- D. Openings and/or hollow spaces are made in a casting with a baked sand core.

VII. The molten metal reaches the cavity through a gating system. (Transparency MW10-15)

- A. The cavity is the hollow area in the mold that forms the shape of the casting.
- B. The gating system includes (1) pouring basin, (2) sprue, (3) sprue base, (4) runners, (5) gates, and (6) risers.
  1. The pouring basin receives the molten metal from the ladle.
  2. The sprue is the vertical opening through which the molten metal enters the flask. (Transparency MW10-16)
  3. The sprue base is an enlarged area at the base of the sprue which permits the molten metal to change directions (vertical to horizontal) with the least amount of turbulence.
  4. Runners are horizontal distribution channels.
  5. Gates are the entrances to the mold cavities. (Transparency MW10-17)
  6. Risers are reservoirs of molten metal.
     - a. Risers eliminate shrinkage cavities.
     - b. Risers should be large enough in volume so that they solidify after the casting.

MATERIALS FOR STUDENTS

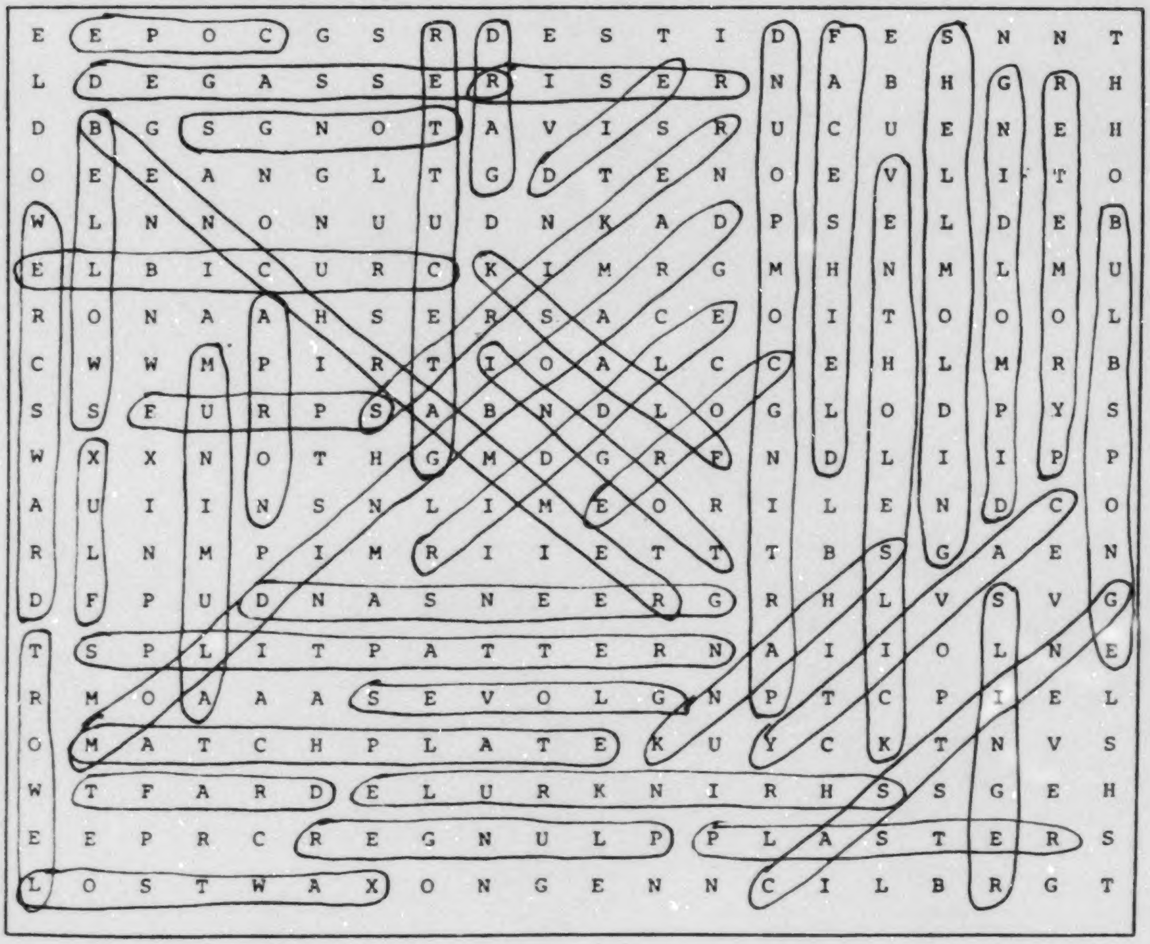
- Vocabulary worksheet
- Newspapers, magazines
- Notebook (preferably a three-ring binder)
- Drawing paper, pens, pencils

SUGGESTED STUDENT ACTIVITIES

1. Make a list of at least five items in each room of your home that are totally or partly cast.
2. Ask students to prepare a poster on foundry safety.

3. Research the work a metallurgist would do in a foundry.
4. Show examples of common types of patterns.
5. Demonstrate the ramming of a mold. Have the students do it with you—step by step—in groups of two. Use a sample flat back pattern.
6. Demonstrate the ramming of a destructive pattern casting. Have students discuss the advantages and disadvantages of this process.

Answer to Handout No. 2



E	E	P	O	C	G	S	R	D	E	S	T	I	D	F	E	S	N	N	T
L	D	E	G	A	S	S	E	R	I	S	E	R	N	A	B	H	G	R	H
D	B	G	S	G	N	O	T	A	V	I	S	R	U	C	U	E	N	E	H
O	E	E	A	N	G	L	T	G	D	T	E	N	O	E	V	L	I	T	O
W	L	N	N	O	N	U	U	D	N	K	A	D	P	S	E	L	D	E	B
E	L	B	I	C	U	R	C	K	I	M	R	G	M	H	N	M	L	M	U
R	O	N	A	A	H	S	E	R	S	A	C	E	O	I	T	O	O	O	L
C	W	W	M	P	I	R	T	I	O	A	L	C	C	E	H	L	M	R	B
S	S	F	U	R	P	S	A	B	N	D	L	O	G	L	O	D	P	Y	S
W	X	X	N	O	T	H	G	M	D	G	R	F	N	D	L	I	I	P	P
A	U	I	I	N	S	N	L	I	M	E	O	R	I	L	E	N	D	C	O
R	L	N	M	P	I	M	R	I	I	E	T	T	T	B	S	G	A	E	N
D	F	P	U	D	N	A	S	N	E	E	R	G	R	H	L	V	S	V	G
T	S	P	L	I	T	P	A	T	T	E	R	N	A	I	I	O	L	N	E
R	M	O	A	A	A	S	E	V	O	L	G	N	P	T	C	P	I	E	L
O	M	A	T	C	H	P	L	A	T	E	K	U	Y	C	K	T	N	V	S
W	T	F	A	R	D	E	L	U	R	K	N	I	R	H	S	S	G	E	H
E	E	P	R	C	R	E	G	N	U	L	P	P	L	A	S	T	E	R	S
L	O	S	T	W	A	X	O	N	G	E	N	N	C	I	L	B	R	G	T

Vocabulary Worksheet

1. Saugus Iron Works
2. John Wilkenson
3. sand slinger
4. jolt squeeze machine
5. production foundry
6. jobbing foundry
7. captive foundry
8. independent foundry
9. destructive foundry
10. investment casting
11. Styrofoam
12. ceramic slurry
13. core
14. parting line
15. permanent mold casting
16. centrifugal casting
17. die casting
18. dip molding
19. slush molding
20. plaster mold casting
21. shell molding
22. thermosetting resin
23. phenolic
24. CO_2 molding
25. crucible furnace

26. pyrometer
27. tongs
28. shank
29. flux
30. green sand
31. synthetic sand
32. flask
33. cope
34. drag
35. bottom board
36. molding board
37. parting dust
38. riddle
39. bench rammer
40. strike-off bar
41. vent wire
42. sprue pin
43. sprue cutter
44. bulb sponge
45. draw sponge
46. draw screw
47. bellows
48. molder tools
49. skimmer
50. simple pattern
51. split pattern
52. match plate

53. shrink rule

54. draft

55. gating system

56. pouring basin

57. sprue

58. sprue base

59. runners

60. gates

61. risers

TEST

UNIT 10: METAL CASTING

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Primitive casting of copper developed--
A. in China
B. in India
C. near the Eurasiatic Steppe
D. in Italy

___ 2. The earliest recorded investment casting was--
A. in China
B. in India
C. near the Eurasiatic Steppe
D. in Italy

___ 3. Iron castings were first made--
A. in China
B. in India
C. near the Eurasiatic Steppe
D. in Italy

___ 4. The most widely used industrial casting technique is--
A. investment casting
B. permanent mold casting
C. shell molding
D. sand casting

___ 5. Which of the following produces one type of casting?
A. jobbing foundries
B. independent foundries
C. production foundries
D. captive foundries

___ 6. Which of the following incorporates low production rates and produces a variety of castings?
A. jobbing foundries
B. independent foundries
C. production foundries
D. captive foundries

___ 7. Which of the following is owned by a large company that uses all or most of the produced castings?
A. jobbing foundries
B. independent foundries
C. production foundries
D. captive foundries

___ 8. Which of the following is normally small, privately owned, and produces castings by contracts with customers?
A. jobbing foundries
B. independent foundries
C. production foundries
D. captive foundries

___ 9. A process that uses a Styrofoam pattern that is vaporized in the sand by the hot metal is--
A. destructive casting
B. centrifugal casting
C. shell molding
D. slush molding

___ 10. A process that uses a ceramic slurry and a wax or polystyrene pattern that is burned out before the metal is poured into the casting is--
A. permanent mold casting
B. die casting
C. investment casting
D. plaster mold casting

___ 11. A permanent mold casting, which is done by pouring metal into a vertical or horizontal revolving mold, is--
A. dip molding
B. CO_2molding
C. sand casting
D. centrifugal casting

___ 12. A nonferrous metal is forced into a mold under pressure in--
A. die casting
B. dip molding
C. sand casting
D. centrifugal casting

___ 13. A form of permanent mold casting which produces a hollow product that is finished on its interior surface is--
A. slush molding
B. dip molding
C. die casting
D. investment casting

___ 14. A form of permanent mold casting which produces a hollow casting with a finished exterior surface is--
A. dip molding
B. centrifugal casting
C. destructive casting
D. slush molding

___ 15. A variation of sand casting, this process uses a phenolic/sand mold:
- A. investment casting
- B. shell molding
- C. centrifugal casting
- D. slush molding

___ 16. Which of the following is not recommended for melting in a school crucible furnace?
- A. aluminum
- B. brass
- C. lead
- D. some iron

___ 17. Which of the following metals is recommended for the beginner?
- A. aluminum
- B. brass
- C. lead
- D. some iron

___ 18. The container used to hold the molding sand for a complete mold is the--
- A. cope
- B. drag
- C. flask
- D. riddle

___ 19. A device used to pack sand into the flask is the--
- A. strike-off bar
- B. bench rammer
- C. molder's tools
- D. draw screw

___ 20. A device used to level the sand in the flask after it has been rammed is the--
- A. strike-off bar
- B. bench rammer
- C. molder's tools
- D. draw screw

___ 21. A device used to cut vertical passageways is the--
- A. sprue pin
- B. sprue cutter
- C. molder's tools
- D. strike-off bar

___ 22. A board on which the pattern and gating system is split along the parting line and mounted back to back to form a single piece is called the--
- A. split pattern
- B. simple pattern
- C. compound pattern
- D. match plate

___ 23. A slight taper on a pattern which permits the pattern to be lifted from the sand without damaging the mold is called the--
A. drift
B. lift
C. draft
D. riser

___ 24. An opening and/or hollow space in a sand casting is usually produced by using a--
A. shell core
B. metal core
C. metal pin
D. sand core

___ 25. The part that receives the molten metal from the ladle is the--
A. pouring basin
B. sprue
C. sprue base
D. riser

___ 26. The vertical opening through which the molten metal enters the flask is the--
A. riser
B. sprue
C. sprue base
D. pouring basin

___ 27. The entrance to the mold cavity is the--
A. gate
B. sprue
C. riser
D. runner

___ 28. The horizontal distribution channels are the--
A. risers
B. sprues
C. runners
D. gates

___ 29. The part that helps to eliminate shrinkage cavities is the--
A. sprue
B. riser
C. runner
D. gate

HANDOUT NO. 1

COMPARISON OF CASTING PROCESSES

	SAND MOLDS			METAL MOLDS		SPECIAL MOLDS	
	GREEN SAND MOLD	DRY SAND MOLD	SHELL MOLD	PERMANENT MOLD	DIE MOLD	INVESTMENT MOLD	PLASTER MOLD
CHIEF MATERIALS FOR MOLD	SAND + CLAY BINDER + MOISTURE	SAND + OIL BINDER + (OVEN BAKE)	SAND + RESIN BINDER + (OVEN CURE)	USUALLY STEEL	HARDENED STEEL	SILICA SAND + SPECIAL BINDER + (AIR & OVEN CURE)	GYPSUM + WATER
USUAL METALS CAST	MOST METALS	MOST METALS	MOST METALS	ALUMINUM, BRASS, BRONZE, SOME IRON	ALLOY OF ALUMINUM, ZINC, MAGNESIUM	SPECIAL ALLOYS	ALUMINUM, BRASS, BRONZE, ZINC
SURFACE FINISH OF CASTING	ROUGH	ROUGH	SMOOTH	SMOOTH	VERY SMOOTH	VERY SMOOTH	VERY SMOOTH
ACCURACY OF CASTING	NOT VERY ACCURATE	NOT VERY ACCURATE	FAIRLY ACCURATE	FAIRLY ACCURATE	VERY ACCURATE	VERY ACCURATE	FAIRLY ACCURATE
USUAL WEIGHT OF CASTINGS	UP TO SEVERAL	UP TO SEVERAL	½ LB. TO 30 LB.	UP TO 15 LB.	UP TO 20 LB.	UP TO 5 LB.	UP TO 20 LB.
COST OF MOLD	LOW	LOW	MEDIUM	HIGH	HIGH	HIGH	MEDIUM

HANDOUT NO. 2
Search for Foundry Terms

Familiar words in foundry activities are found in this puzzle. There are forty-three words hidden here that may appear up, down, forward, backward, or diagonally. All forty-three words are really included. Circle the words as you find them. Have fun—with a learning experience!

aluminum
apron
bellows
bench rammer
bulb sponge
casting
cavity
cope
core
crucible
degasser
die
dip molding
draft
drag
draw screw
face shield
flask
flux
gate cutter
gloves
green sand
ingot
lost wax
match plate
molding board
parting board
plaster
plunger
pyrometer
riddle
riser
shank
shell molding
shrink rule
slick
slinger
split pattern
sprue
striker
tongs
tongs
trowel
vent holes

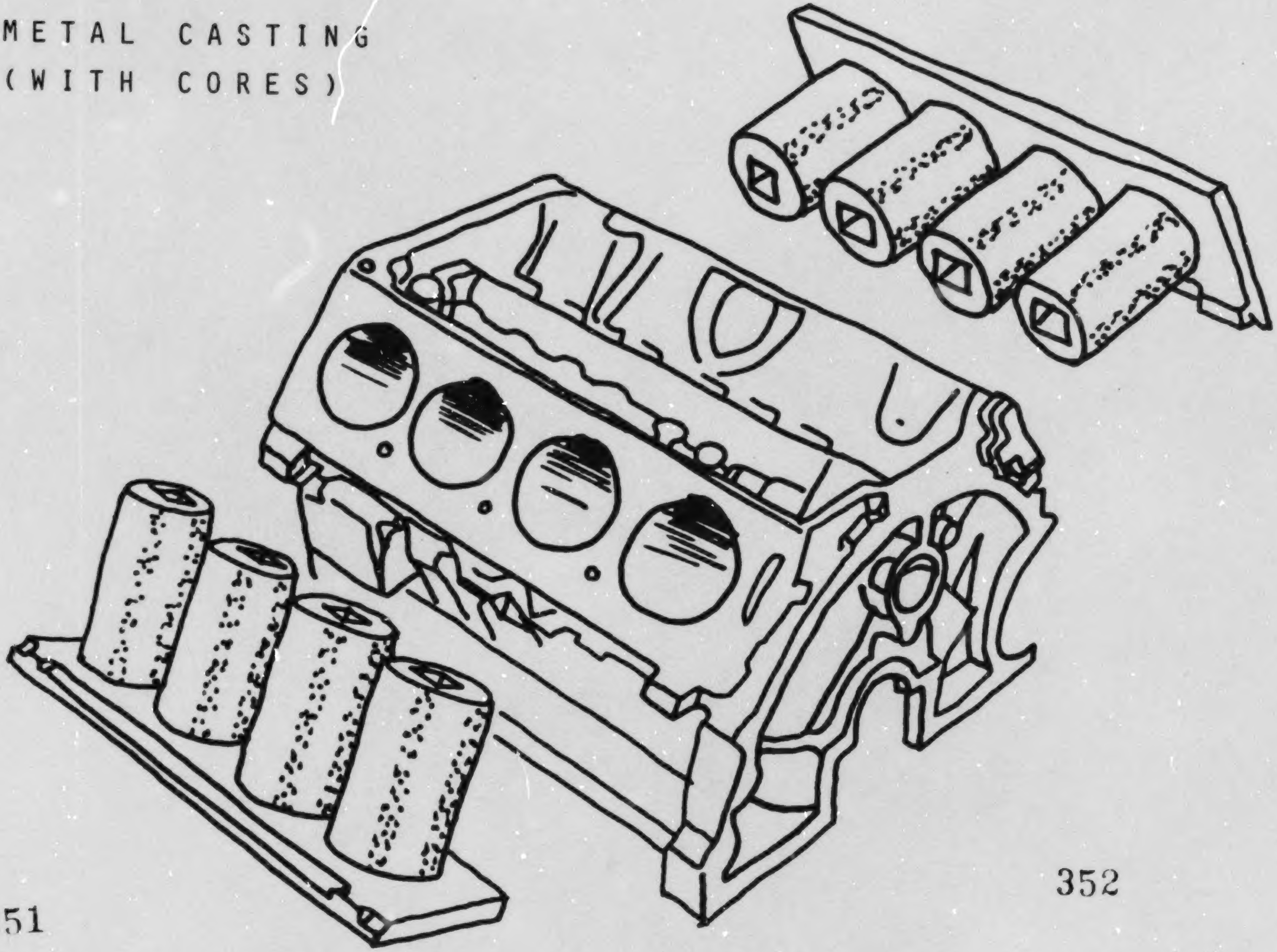
E	E	P	O	C	G	S	R	D	E	S	T	I	D	F	E	S	N	N	T
L	D	E	G	A	S	S	E	R	I	S	E	R	N	A	B	H	G	R	H
D	B	G	S	G	N	O	T	A	V	I	S	R	U	C	U	E	N	E	H
O	E	E	A	N	G	L	T	G	D	T	E	N	O	E	V	L	I	T	O
W	L	N	N	O	N	U	U	D	N	K	A	D	P	S	E	L	D	E	B
E	L	B	I	C	U	R	C	K	I	M	R	G	M	H	N	M	L	M	U
R	O	N	A	A	H	S	E	R	S	A	C	E	O	I	T	O	O	O	L
C	W	W	M	P	I	R	T	I	O	A	L	C	C	E	H	L	M	R	B
S	S	F	U	R	P	S	A	B	N	D	L	O	G	L	O	D	P	Y	S
W	X	X	N	O	T	H	G	M	D	G	R	F	N	D	L	I	I	P	P
A	U	I	I	N	S	N	L	I	M	E	O	R	I	L	E	N	D	C	O
R	L	N	M	P	I	M	R	I	I	E	T	T	T	B	S	G	A	E	N
D	F	P	U	D	N	A	S	N	E	E	R	G	R	H	L	V	S	V	G
T	S	P	L	I	T	P	A	T	T	E	R	N	A	I	I	O	L	N	E
R	M	O	A	A	A	S	E	V	O	L	G	N	P	T	C	P	I	E	L
O	M	A	T	C	H	P	L	A	T	E	K	U	Y	C	K	T	N	V	S
W	T	F	A	R	D	E	L	U	R	K	N	I	R	H	S	S	G	E	H
E	E	P	R	C	R	E	G	N	U	L	P	P	L	A	S	T	E	R	S
L	O	S	T	W	A	X	O	N	G	E	N	N	C	I	L	B	R	G	T

HANDOUT NO. 3
Causes of Casting Failures
(After Pouring)

1. Permeability of sand
2. Not using a flux
3. Gates too small
4. Plasticity of molding sand is too low
5. Wrong grade and size of sand
6. Improperly tempered sand (wet or dry)
7. Low refractory point of sand
8. Uneven ramming of mold
9. Not venting
10. Using a riddle which is too large
11. Improper gating—or failure to gate at all
12. Improper risers
13. Foreign matter in the sand
14. Leaving loose sand in the gates and/or mold
15. Rough gates
16. Pouring the metal at an improper temperature
17. Failure to use the proper fluxes
18. Using parting compound improperly
19. Improper pouring of the metal
20. Removing casting too soon from the mold
21. Digging into the casting before it hardens
22. Improper pattern arrangement in the mold
23. Putting the drag and cope together in reverse positions
24. Separating the flask unevenly
25. Rough handling of the mold which resulted in the breaking of the green sand
26. Failure to cover the sprue and risers
27. Failure to draft properly
28. Improper locking of flask
29. Adding too much water in the repairing of the mold
30. Improperly made patterns
31. Failure to ram up both halves of a split pattern
32. Pouring hole too small
33. Risers too small
34. Failure to remove pattern from the mold
35. Failure to cut gates and/or runners

METAL CASTING
(WITH CORES)

MW10-1



MW10-2

DESTRUCTIVE CASTING IN THE SCHOOL LAB

1. MAKE THE PATTERN FROM STYROFOAM
2. ATTACH A STYROFOAM SPRUE AND RISERS WITH GLUE OR WIRE PIN (GLUE IS BETTER)
3. FILL FLASK AND PACK SOLID TO A DEPTH OF ABOUT 2-INCHES
4. PLACE PATTERN ON SAND
5. RIDDLE SAND AND COVER PATTERN TO A DEPTH OF ABOUT 2-INCHES
6. PACK WELL WITH FINGERS
7. FILL FLASK AND RAM FIRM
8. POUR METAL
9. ALLOW TO COOL AND REMOVE

INVESTMENT CASTING

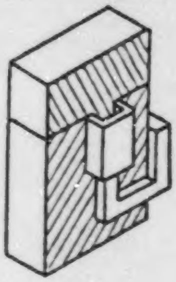


FIGURE 1

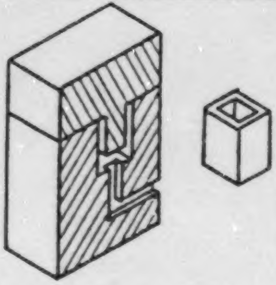


FIGURE 2

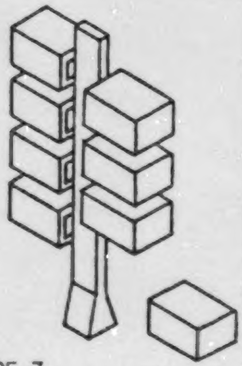


FIGURE 3

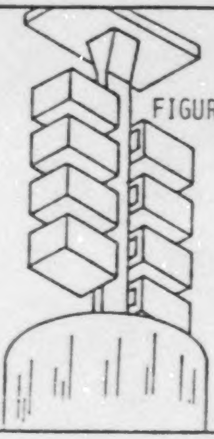


FIGURE 4

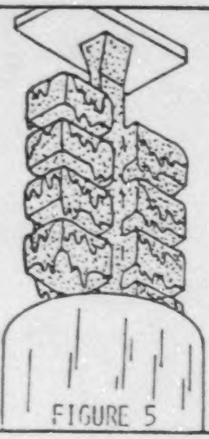


FIGURE 5

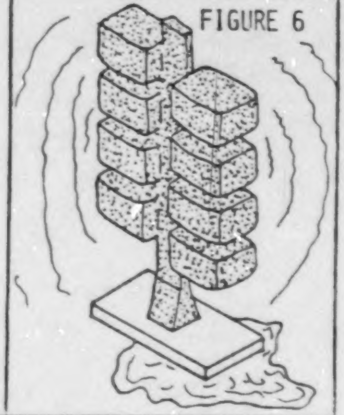


FIGURE 6

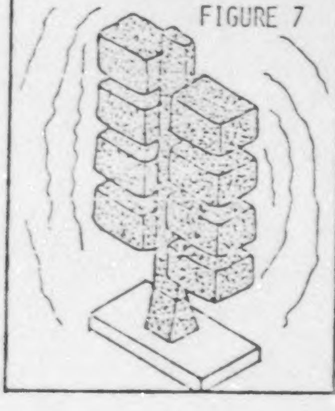


FIGURE 7

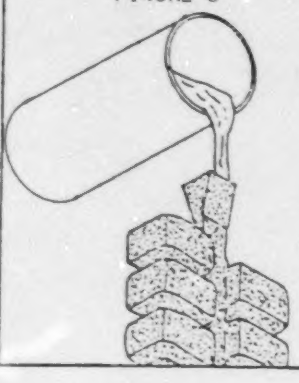


FIGURE 8

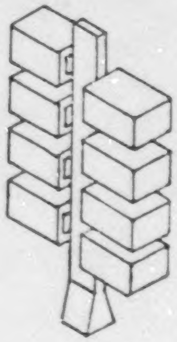
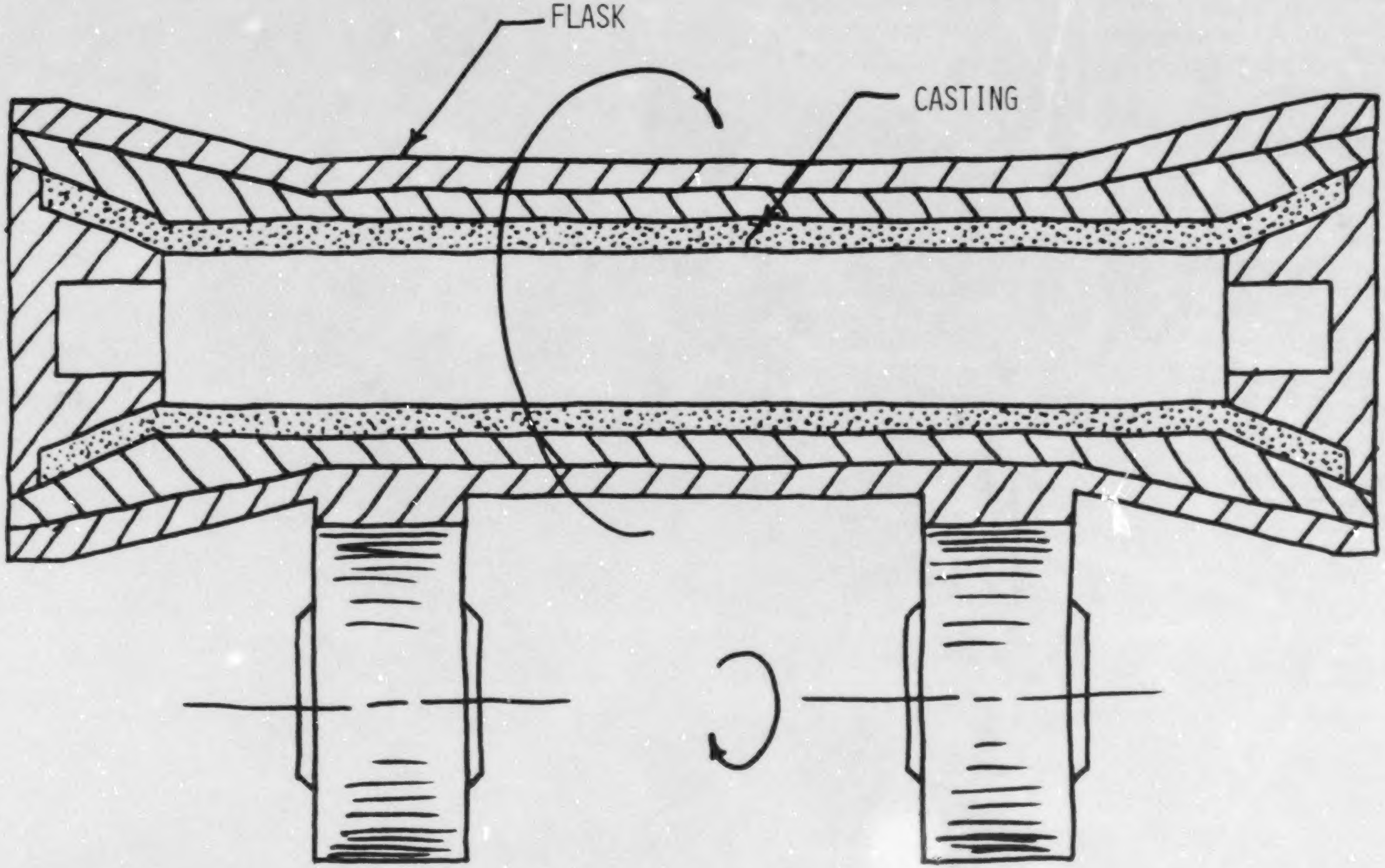


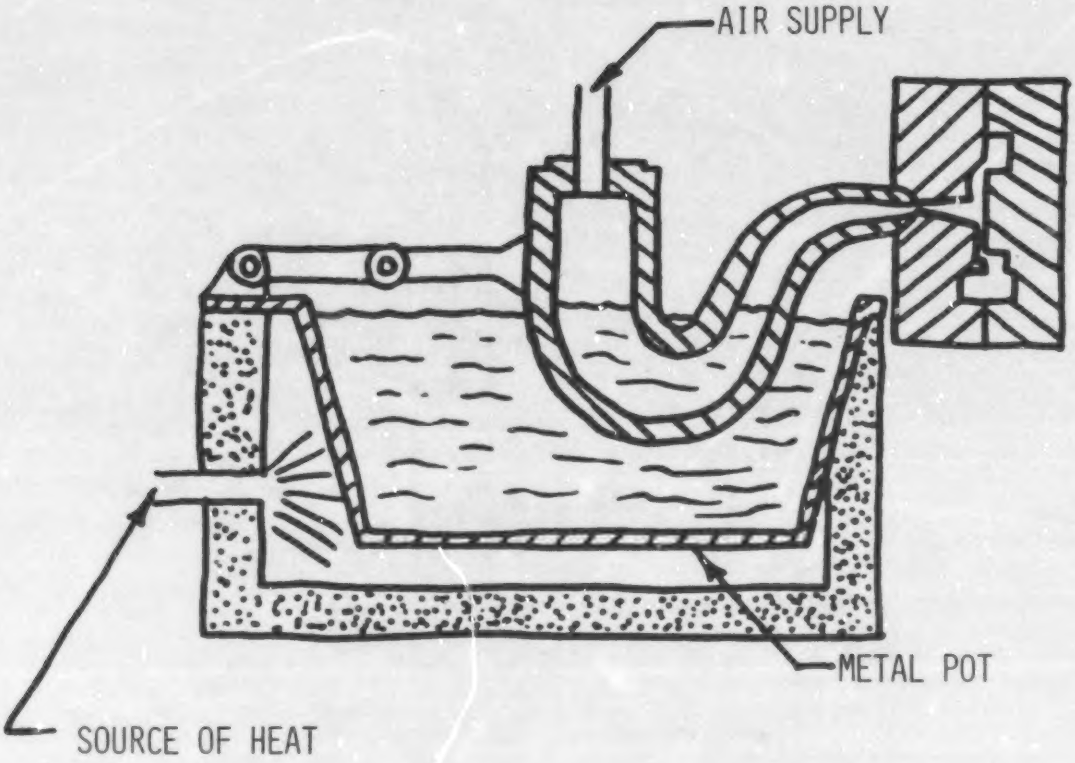
FIGURE 9

CENTRIFUGAL CASTING MACHINE

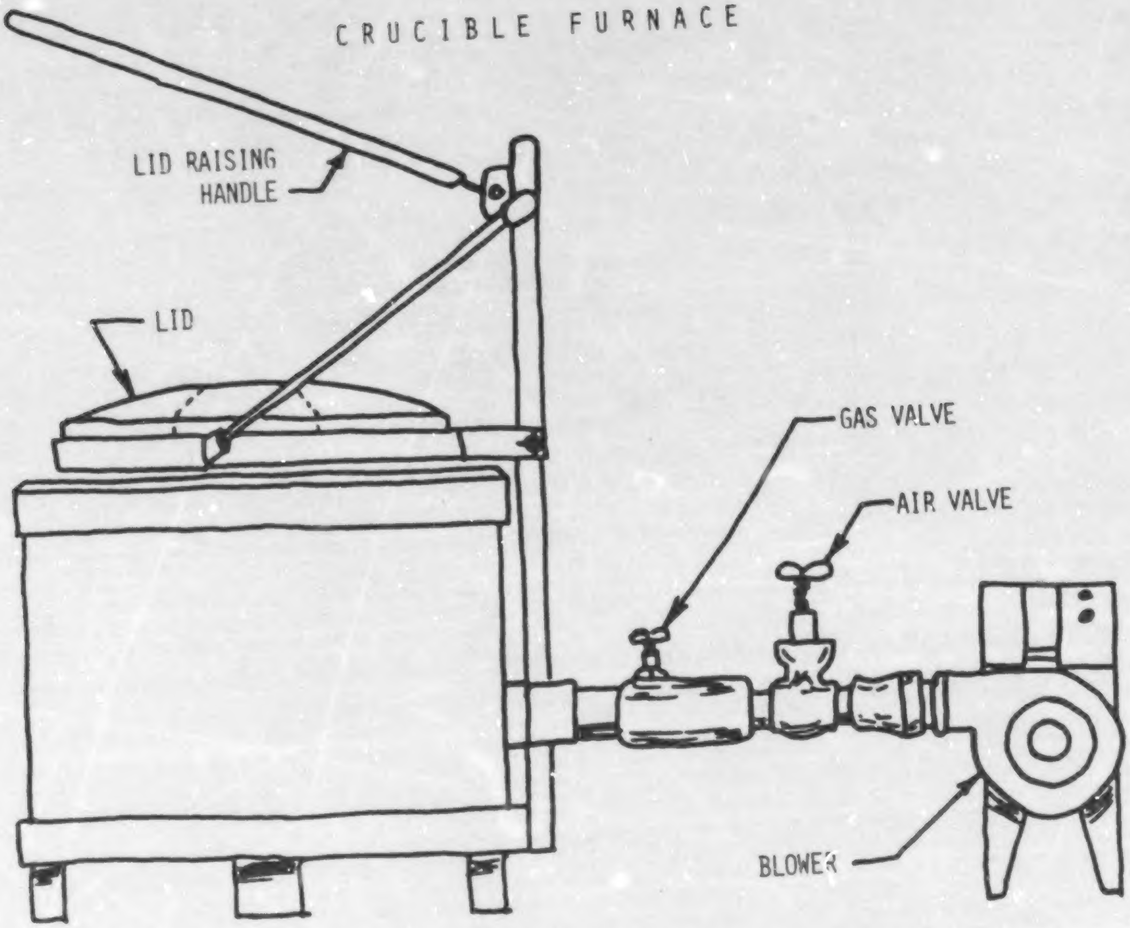

FLASK
CASTING

MW10-4

DIE CASTING


AIR SUPPLY
METAL POT
SOURCE OF HEAT

CRUCIBLE FURNACE


LID RAISING HANDLE
LID
GAS VALVE
AIR VALVE
BLOWER

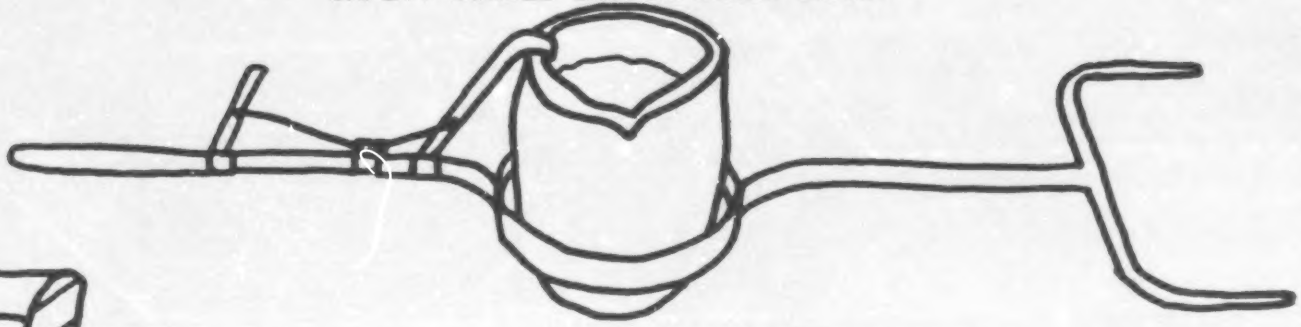
TO LIGHT A CRUCIBLE FURNACE

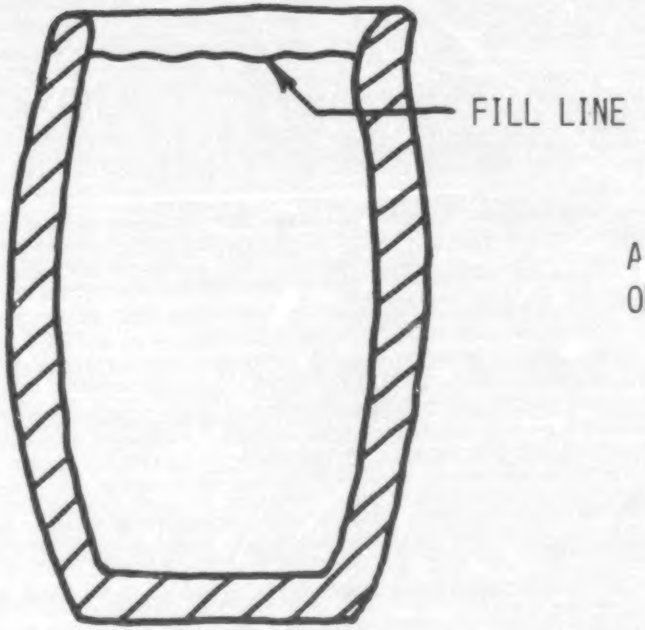
1. OPEN LID
2. TURN ON BLOWER
3. OPEN AIR VALVE
4. PURGE FURNACE FOR ABOUT 30 SECONDS
5. TURN ON IGNITER SWITCH
6. SLOWLY OPEN GAS VALVE
7. TURN OFF IGNITER SWITCH
8. ADJUST AIR SUPPLY WITH AIR VALVE
9. CLOSE LID

CRUCIBLES

MW10-8

SAFETY SINGLE END CRUCIBLE SHANK





361

A NUMBER 16 STANDARD CRUCIBLE HOLDS 16 POUNDS OF LIQUID ALUMINUM

362

MELTING TEMPERATURES OF METALS

METAL	DEGREES (°F)
CERROBEND ALLOY	158
PEWTER	420
LEAD	621
GAR-ALLOY	830
ALUMINUM	1218
BRONZE	1675
BRASS	1700
COPPER	1981
CAST IRON	2200
STEEL	2500

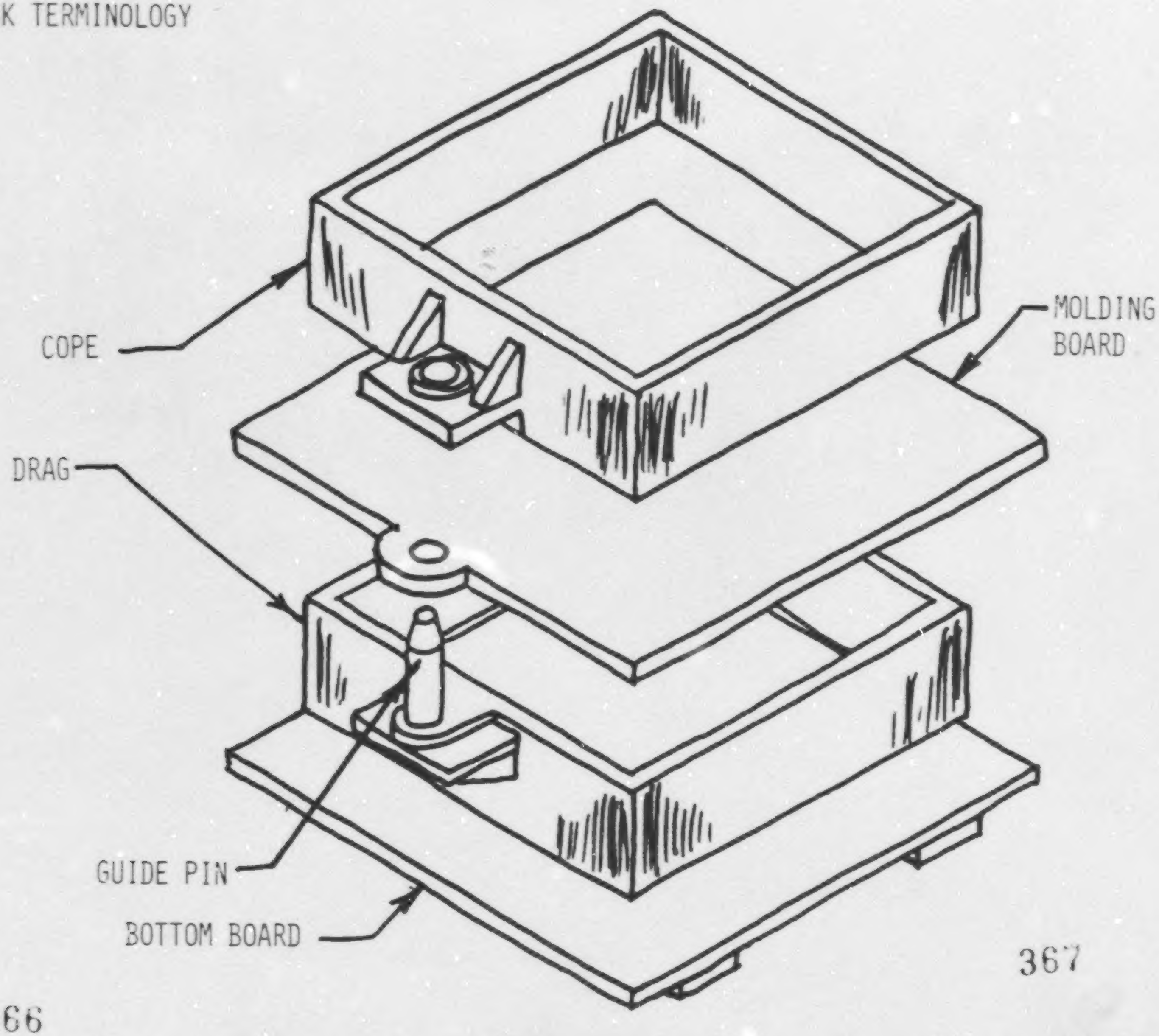
FOUNDRY RULES & REGULATIONS

1. KEEP WATER AWAY FROM MOLTEN METAL AND THE POURING AREA
2. NEVER LIFT A FILLED MOLD BY YOURSELF
3. THE FLOOR AROUND THE FURNACE AND POURING AREA SHOULD BE CLEAR AT ALL TIMES
4. ARRANGE MOLDS WITH SPRUES ALL ON THE SIDE TO BE POURED
5. ONLY THE 2 POURERS AND 1 ASSISTANT SHOULD BE IN THE POURING AREA
6. BE SURE THAT THE CRUCIBLE IS IN GOOD CONDITION
7. CHECK THE CRUCIBLE TONGS AND THE SHANK FOR PROPER ADJUSTMENT BEFORE BEGINNING
8. NEVER ADD WET OR MOIST METAL TO A MELT
9. STUDY THE FURNACE START-UP AND SHUTDOWN PROCEDURE BEFORE BEGINNING
10. NEVER ATTEMPT TO BREAK OPEN A HOT MOLD

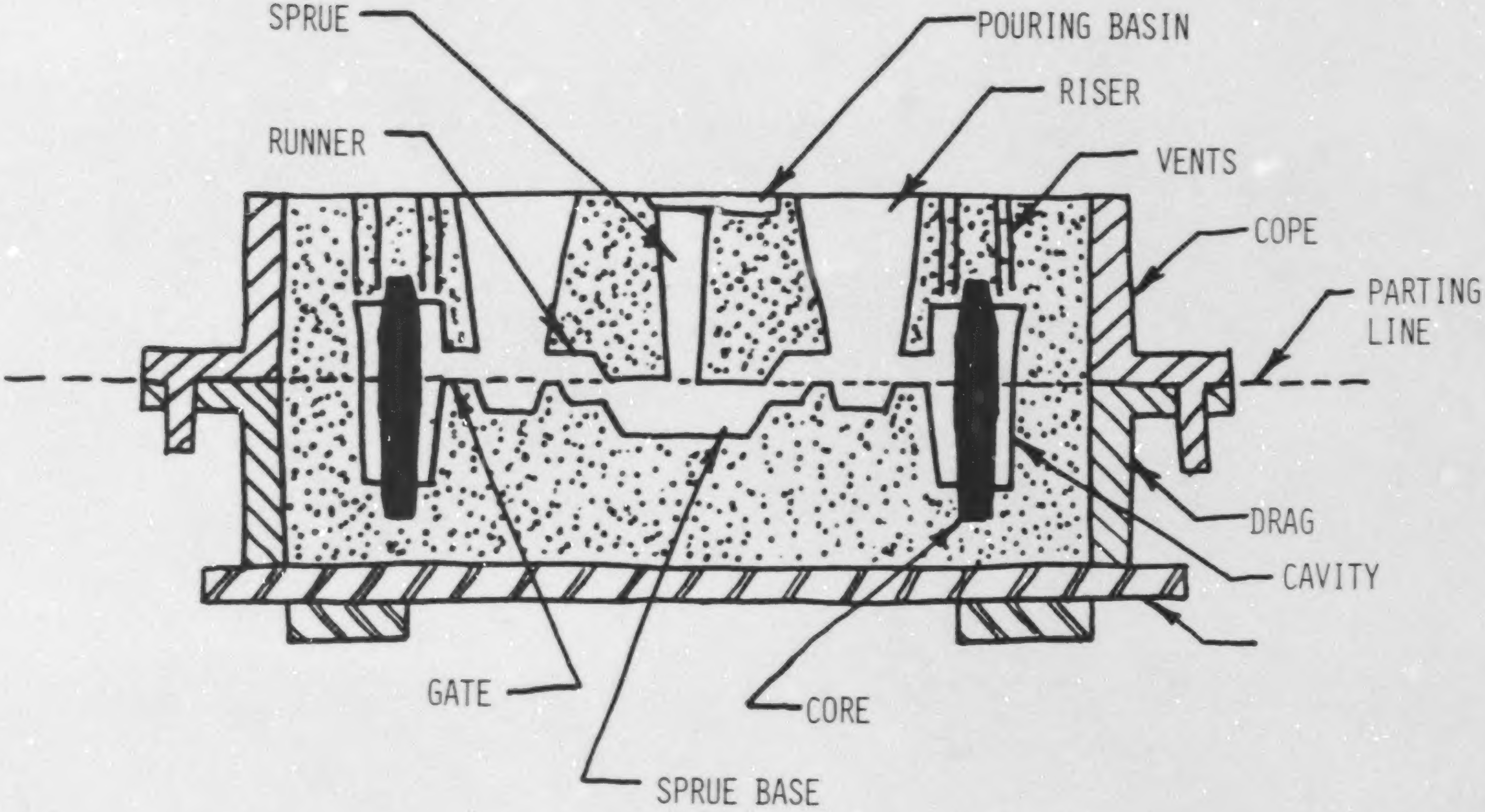
MW10-10

MW10-11

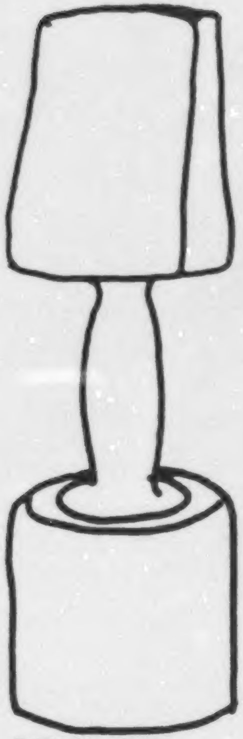
FLASK TERMINOLOGY


COPE
MOLDING BOARD
DRAG
GUIDE PIN
BOTTOM BOARD

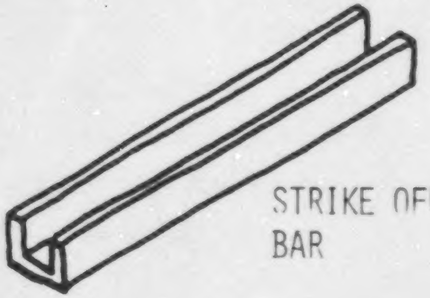
SAND MOLD


SPRUE
POURING BASIN
RISER
RUNNER
VENTS
COPE
PARTING LINE
DRAG
CAVITY
GATE
CORE
SPRUE BASE

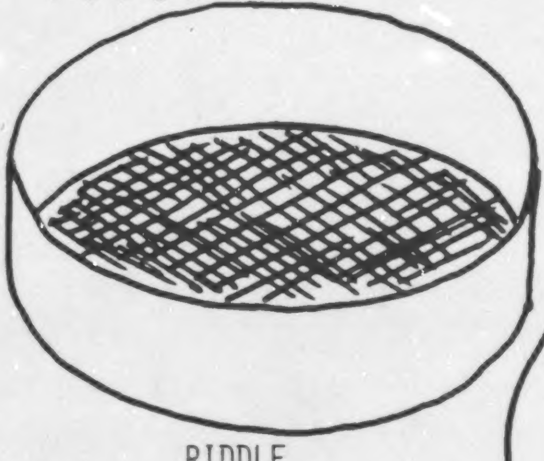
FOUNDRY TOOLS



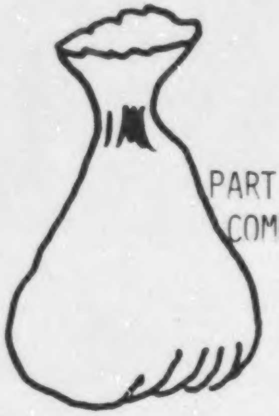
BENCH RAM



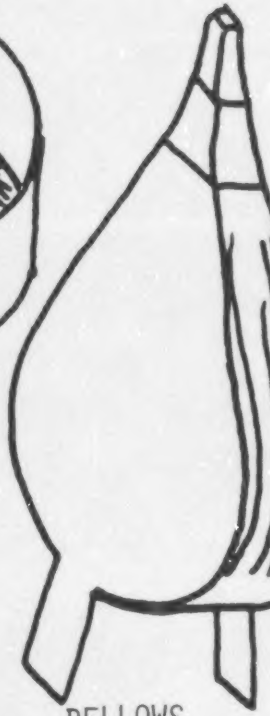
STRIKE OFF BAR



RIDDLE

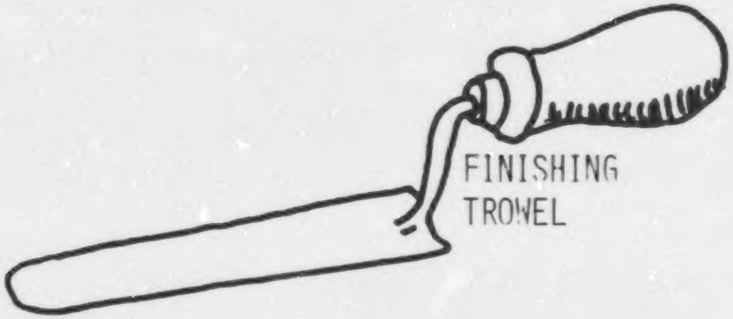


PARTING COMPOUND

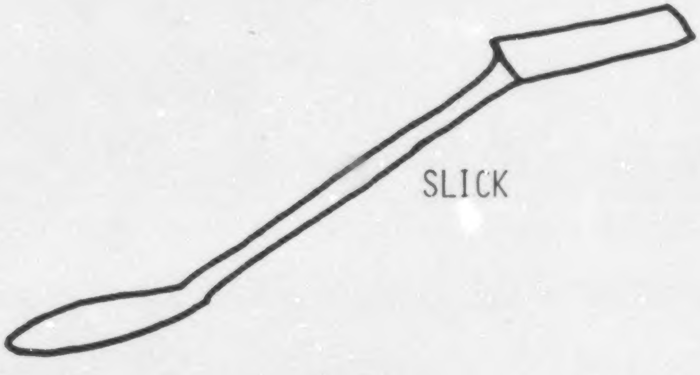


BELLOWS

MW10-13



FINISHING TROWEL



SLICK

RAMMING THE DRAG

1. PLACE THE MOLDING BOARD ON THE BENCH
2. PLACE THE DRAG HALF OF THE FLASK ON THE MOLDING BOARD WITH THE GUIDE PINS THROUGH THE BOARD
3. POSITION THE PATTERN ON THE MOLDING BOARD
4. DUST THE PATTERN & MOLDING BOARD WITH PARTING COMPOUND
5. RIDDLE SAND INTO THE DRAG COVERING THE PATTERN WITH ABOUT 1-INCH OF SAND
6. PACK SAND FIRMLY AND CAREFULLY AROUND THE PATTERN WITH YOUR FINGERS
7. SHOVEL SAND INTO THE DRAG UNTIL IT IS OVERFLOWING
8. RAM THE EDGES WITH THE TAPERED END OF THE BENCH RAMMER
9. USE THE FLAT END OF THE BENCH RAMMER AND RAM SOLID

MW10-14A

MW10-14B

10. LEVEL THE SAND WITH THE STRIKE-OFF BAR
11. PLACE THE BOTTOM BOARD OVER THE DRAG
12. ASK A FRIEND TO ASSIST YOU AND CAREFULLY TURN THE MOLDING BOARD, DRAG, & BOTTOM BOARD OVER

MARKING FOR THE GATING SYSTEM

1. CAREFULLY STUDY THE PATTERN AND DETERMINE WHERE THE SPRUE AND RISER(S) WILL BE
2. REMOVE THE MOLDING BOARD
3. MAKE A THUMB PRINT INTO THE SAND OF THE DRAG AT THE LOCATION OF THE SPRUE
4. MAKE A FINGER INDENTATION WITH YOUR LITTLE FINGER AT THE LOCATION OF EACH RISER

RAMMING THE COPE

1. SET THE COPE ONTO THE DRAG
2. IF USING A SPLIT PATTERN, SET THE SECOND HALF IN PLACE
3. DUST THE PATTERN LIGHTLY WITH PARTING COMPOUND
4. REPEAT THE RIDDLING, PACKING, RAMMING, AND STRIKE-OFF PROCEDURE AS WITH THE DRAG
5. CUT VENTS INTO THE SAND TO ABOUT 1/4-INCH ABOVE THE PATTERN
6. CAREFULLY SEPARATE THE COPE FROM THE DRAG AND SET IT ON A MOLDING BOARD-UPSIDE DOWN

CUTTING A GATING SYSTEM

1. THE SPRUE BASE SHOULD BE RECTANGULAR AND AT LEAST TWICE THE SIZE OF THE SPRUE
2. THE RUNNERS SHOULD GRADUALLY TAPER AS THEY REACH THEIR END
3. GATES SHOULD HAVE CURVED INLETS TO SMOOTH OUT THE METAL FLOW INTO THE MOLD CAVITY
4. GATES SHOULD NOT ENTER THE CAVITY WHERE THERE IS ANY DETAIL
5. CUT THE SPRUE HOLE AND RISER HOLE(S) INTO THE COPE
6. CUT THE SPRUE BASE, ALL RUNNERS, AND GATES INTO THE DRAG
7. CAREFULLY REMOVE THE PATTERN
8. BE SURE ALL GATES ARE CUT INTO THE CAVITY

MW10-17A

9. CARVE YOUR INITIALS BACKWARDS INTO THE BACK OR BASE ON THE CAVITY
10. USING BELLOWS, BLOW ALL LOOSE SAND FROM THE CAVITY AND GATING SYSTEM
11. TURN THE COPE ON ITS SIDE
12. ENLARGE SLIGHTLY THE TOP OF THE SPRUE
13. CARVE OUT A RECTANGULAR POURING BASIN AGAINST ONE SIDE OF THE SPRUE
14. GREATLY ENLARGE ALL RISERS
15. USING BELLOWS, BLOW OUT ANY LOOSE SAND
16. CAREFULLY REPOSITION THE COPE ONTO THE DRAG--BE SURE IT IS SECURE
17. LEAVE THE BOTTOM BOARD UNDER THE FLASK AND SET THE FLASK IN THE POURING AREA
18. CARVE YOUR INITIALS IN THE SAND FOR IDENTIFICATION
19. COVER YOUR FLASK WITH A MOLDING BOARD

MW10-17B

11

Sheet Metal Work

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. list the most common sheet metals and their sizes;
2. correctly measure sheet metal;
3. describe the industrial stamping process;
4. correctly use various punching processes;
5. correctly use various snips and shears;
6. correctly form sheet metal using various hand and machine tools;
7. correctly form sheet metal seams; and
8. correctly join sheet metal using seams, epoxy cement, spot welding, and soldering.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

plate
stamping
cycle time
solid punch
hand punch
hollow punch
turnet punch press
combination snips
aviation snips
throatless hand shear
bench shear
squaring shear
treadle
portable electric shear
ring and circle shear
nippers
hem
beading
wired edge
stake
hand seamer
brake
bar folder
slip roll
easy edger
rotary machine
seam
rivet set
riveting hammer
grooving tool
epoxy cement
spot welding
solder
hard soldering
soft soldering
flux
rosin
zinc chloride
muriatic acid
Sal ammoniac

TEACHING AIDS

- Overhead projector
- Test Key: 1-D, 2-B, 3-C, 4-A, 5-C, 6-C, 7-C, 8-D, 9-B, 10-B, 11-D, 12-A, 13-C, 14-A, 15-A, 16-D, 17-D, 18-B, 19-C, 20-A, 21-A.

- Transparencies and Handouts: You will find transparencies MW11-1 through MW11-15 and Handout No. 1 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

MW11-1: Basic Sheet Metal Hand Tools
MW11-2: Hand Punch
MW11-3: How to Use the Hand Punch
MW11-4: Shears
MW11-5: Squaring Shear
MW11-6: Ring and Circle Shear
MW11-7: Examples of Forming Operations
MW11-8: Brake
MW11-9: Bar Folder
MW11-10: Slip Roll Forming Machine
MW11-11: Easy Edger (Combination Rotary Machine)
MW11-12: Rotary Machine
MW11-13: How to Hand Rivet
MW11-14: How to File and Tin a Soldering Copper
MW11-15: Gas-Fired Bench Furnace

Handout No. 1: Sizes of Hollow Punches

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SENTENCE OUTLINE

I. History
  A. Sheet metal has been in wide use for about 100 years. It was first introduced during the 17th century.
  B. The more common sheet metals are steel, galvanized steel, tin plate, aluminum, copper, brass, and stainless steel.
    1. Sheet metal is 1/8" or less in thickness.
    2. The most common sizes of metal sheets are either 30" or 36" in width and either 96" or 120" in length.
    3. Most sheet metal is measured according to gauge number.
      a. The lighter gauges of sheet metal are usually purchased in rolls.
      b. The higher the gauge number, the thinner the sheet metal.

        c. Aluminum sheets are measured by decimal thickness.
        d. Copper sheets are measured in ounces per square foot.
    C. Plate is greater than 1/8" in thickness.

II. Industrial stamping process
    A. A stamping is a metal part produced from sheet or strip metal by cutting, forming, or drawing by mechanical means. (Transparency MW11-1)
    B. Splash pans and door panels are obvious choices for parts to be stamped.
    C. Parts such as generator end plates and rear axle housings were once cast and machined, but are now stamped.
    D. Once proper tooling has been produced, stampings can be turned out at great speed.
        1. Stamping cycle time is much shorter than for forging or machining.
        2. Large panels can be produced at a rate of over 400 per hour.
        3. Small parts can be stamped out at rates up to 18,000 per hour.

III. Separating (Transparency MW11-2)
    A. The solid punch makes small holes in sheet metal—usually for nails and/or screws. (Transparency MW11-3)
    B. A hand punch consists of a die and a punch moved by levers.
        1. The punch forces the metal through the die, leaving a clean hole.
        2. The die acts as a backing instead of a wood block or lead cake.
    C. Hollow punches are rods of tool steel having hollow ends with beveled cutting edges. (Handout No. 1)
        1. Some have a center pin to aid in centering the punch.
        2. The shank is knurled to give a better grip.
    D. A bench (or floor) lever punch is used for punching heavier gauges of sheet metal, and for larger holes.
    E. A turret punch press is equipped with various sizes of punches and dies to eliminate frequent changing.
    F. Hand snips
        1. Combination snips are used to cut straight lines and irregular lines that have a large arc or radius.
        2. Aviation snips
            a. Right-hand aviation snips cut small curves toward the right and have green grips.
            b. Left-hand aviation snips cut small curves toward the left and have red grips.
            c. Straight aviation snips are used to cut straight lines, usually into small corners, and have yellow grips.
        3. Never use snips to cut nails, bolts, wire, or hardened metal.
    G. The throatless hand shear is designed for straight and irregular cutting.
    H. The bench shear is similar to a large pair of scissors (2 to 4 feet long), one handle of which is held in a vise or bench plate, and can cut up to 16 gauge sheet metal. (Transparency MW11-4)
    I. A squaring shear is used to cut and square sheet metal to the required size. (Transparency MW11-5)
        1. A squaring shear cuts large sheets into smaller usable sizes.
            a. Only one sheet should be cut at a time.
            b. Never cut sheet metal that exceeds the rated capacity of the squaring shear.
        2. The squaring shear is either foot operated or power operated.
        3. The treadle should be fitted with a stop block to prevent it from going to the floor and possibly injuring the operator's foot.
        4. The power squaring shear is used for high-volume production and for thicker stock.

J. Portable electric shears are used to cut up to 16 gauge large sheets of mild steel.
K. A ring and circle shear is used to cut a large arc or circle. (Transparency MW11-6)
L. A combination notcher, coper, and shear is used for cutting notches.
  1. A notch is a portion of material that is removed from a pattern before it is formed.
  2. A notch eliminates overlapping.
M. Use nippers to cut wire.

IV. Forming (Transparency MW11-7)
A. Definitions
  1. Hems add to the appearance, strength, and safety of sheet metal products.
    a. Hems are usually 1/4".
    b. A single hem is an edge folded over 180°.
    c. A double hem is a single hem folded 180° a second time to completely hide the cut edge.
  2. Beading is for decorating and stiffening purposes and is done on a combination rotary machine.
  3. A wired edge is a rounded edge in which the sheet metal is wrapped around a wire.
B. Sheet metal stakes are used with a mallet to form various objects.
  1. Sheet metal stakes fit securely into special holes in a special bench plate.
  2. Sheet metal stakes come in various shapes for specific operations.
C. Small hand tools
  1. Hand seamers are a plierlike tool used for bending edges or folding seams.
  2. The vise-grip hand seamer is used as a hand seamer, except that it can be locked to the sheet metal parts.
  3. The flat-nose plier is used to bend small square corners in sheet metal.
D. A brake is used to bend sheet metal. (Transparency MW11-8)
  1. A standard hand brake bends sheet metal to various angles.
  2. The box and pan brake has interchangeable and removable fingers and is used for forming four-sided pans and boxes.
  3. Large hydraulic power brakes are used for heavy-duty, high-production sheet metal bending operations.
E. The bar folder is a bench machine used to fold edges of 22 gauge and lighter sheet metal. (Transparency MW11-9)
F. A slip roll forming machine is used to form a curved or cylindrical shape. (Transparency MW11-10)
G. The easy edger is used for making a 1/4", 90° bend on flat, curved parts. (Transparency MW11-11)
H. The rotary machine incorporates various types of rolls and is used for various forming and cutting operations. (Transparency MW11-12)

V. Combining
A. Seams are used to join two pieces of sheet metal. (Transparency MW11-13)
  1. The lap seam is the simplest sheet metal seam with the normal overlap being 1/4".
    a. A riveted lap seam is a lap seam that is held together with rivets.
    b. The riveted lap seam should be used for metals No. 18 gauge and heavier.
    c. A rivet set is used with a riveting hammer to form the finished head of a tinner's rivet.
  2. A grooved lock seam is formed with a hand grooving tool.
    a. A grooved lock seam should be used for metals No. 20 gauge and lighter.
    b. A grooving tool is used with the riveting hammer to make a grooved lock seam.

B. Sheet metal can be fastened with epoxy cement.
1. Epoxy cement comes in two parts that are mixed prior to use.
2. Epoxy cement is used to fasten jet airplane parts together.

C. Spot welding is a form of resistance welding that is used to fasten sheet metal.
1. Spot welding is generally used for steel and stainless steel sheet metal.
2. Spot welders are available as a floor model and a portable model.

D. Soldering is a metal joining method that involves use of a filler metal (solder) with a lower melting point than that of the pieces being joined.
1. Solder is purchased in the form of either wire or bar.
a. Solder is designated by its proportion of tin to lead, with 50/50 solder recommended for school laboratories.
b. Hard soldering uses solder with a melting point about 750°F.
c. Soft soldering used solder with a melting point below 750°F.
2. Flux prepares the sheet metal surfaces for soldering.
a. Flux is either corrosive or noncorrosive.
(1) Rosin is a noncorrosive flux which works well on tin plate and copper.
(2) Zinc chloride is the most common corrosive flux for school laboratories and is a mixture of hydrochloric acid and zinc.
(3) Muriatic acid is a commercial grade of hydrochloric acid which is used as a corrosive flux.
b. Flux assists the solder in spreading and penetrating.
c. Flux removes metallic oxide.
d. Flux prevents further forming of oxide.
e. Flux can be purchased as a powder, paste, lump, or liquid.
3. Sal ammoniac is used to clean a soldering copper so the solder will then adhere to the copper. (Transparency MW11-14)
a. Sal ammoniac is a muriate of ammonia.
b. Sal ammoniac can be obtained in blocks.
4. Soldering irons are the tools used to melt the solder and heat the metal to be joined.
a. The best method of heating soldering copper is with a gas furnace. (Transparency MW11-15)
b. Use two soldering coppers so the second is being heated while the first is being used.
c. A 200- to 300-watt electric soldering iron should be used for light-duty sheet metal products.
5. Use a soldering gun for soldering electrical components.

E. Nuts and bolts are seldom used for sheet metal.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pens, pencils
- Notebook (preferably a three-ring binder)
- Sheet metal gauge
- Small pieces of sheet metal in various thicknesses

SUGGESTED STUDENT ACTIVITIES

1. Identify five major industries that use extensive amounts of sheet metal in their products.
2. Identify sheet metal products in every room of your home. Try to identify and/or sketch the various seams and hems employed.

3. Prepare posters on sheet metal safety.
4. Using clear acrylic, construct scale models of the most common sheet metal seams and hems. Ask students to identify each, and tell how each is made.
5. Ask students to determine the gauge of various small pieces of sheet metal.
6. Give each student a different template. Have each student cut and form the object and fasten it with a spot welder. Discuss the problems encountered in cutting and forming the various objects.

Vocabulary Worksheet

1. plate
2. stamping
3. cycle time
4. solid punch
5. hand punch
6. hollow punch
7. turret punch press
8. combination snips
9. aviation snips
10. throatless hand shear
11. bench shear
12. squaring shear
13. treadle
14. portable electric shear
15. ring and circle shear
16. nippers
17. hem
18. beading
19. wired edge
20. stake
21. hand seamer
22. brake
23. bar folder
24. slip roll
25. easy edger

26. rotary machine

27. seam

28. rivet set

29. riveting hammer

30. grooving tool

31. epoxy cement

32. spot welding

33. solder

34. hard soldering

35. soft soldering

36. flux

37. rosin

38. zinc chloride

39. muriatic acid

40. Sal ammoniac

TEST
UNIT 11: SHEET METAL WORK

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Which of the following is not a common sheet metal?
A. steel
B. aluminum
C. brass
D. tin

___ 2. Tin plate is measured by--
A. decimal thickness
B. gauge number
C. ounces per square foot
D. weight per roll

___ 3. Which of these processes produces a metal part from sheet or strip metal by cutting, forming, or drawing by mechanical means?
A. punching
B. pressing
C. stamping
D. notching

___ 4. A tool that makes small holes in sheet metal, usually for nails and/or seams, is the--
A. solid punch
B. die
C. hollow punch
D. lever punch

___ 5. A punch with a knurled shank and with a center pin to aid in centering is the--
A. solid punch
B. die
C. hollow punch
D. lever punch

___ 6. Which of these is similar to a large pair of scissors (2 to 4 feet long) and is used to cut up to 16 gauge sheet metal?
A. combination snips
B. aviation snips
C. throatless hand shear
D. bench shear

___ 7. Which of these is a bench-mounted machine designed to cut large arcs and circles?
A. portable electric shear
B. bench shear
C. ring and circle shear
D. squaring shear

___ 8. Wire is cut with--
A. hand snips
B. coper
C. notcher
D. nippers

___ 9. Which of these adds to the appearance, strength, and safety of sheet metal?
A. seam
B. hem
C. notch
D. coper

___ 10. Which of these is formed on a combination rotary machine and is used for decorating and stiffening sheet metal products?
A. hem
B. bead
C. notch
D. seam

___ 11. The machine used to form four-sided boxes is the--
A. hand brake
B. easy edger
C. bar folder
D. box and pan brake

___ 12. The machine used to form cylinders is the--
A. slip roll forming machine
B. box and pan brake
C. bar folder
D. rotary machine

___ 13. A machine that incorporates various types of rolls and is used for various forming and cutting operations is the--
A. easy edger
B. slip roll forming machine
C. rotary machine
D. box and pan brake

___ 14. A metal joining method that involves use of a filler metal is--
A. soldering
B. riveting
C. epoxy cementing
D. spot welding

___ 15. The melting point (^{o}F) that separates hard soldering from soft soldering is--
A. 750^{o}
B. 850^{o}
C. 950^{o}
D. 1,000^{o}

___ 16. Which of the following is a noncorrosive flux?
A. muriatic acid
B. hydrochloric
C. metallic oxide
D. rosin

___ 17. Which of the following is **not** a characteristic of flux?
A. is corrosive or noncorrosive
B. assists the solder in spreading and penetrating
C. removes metallic oxide
D. initiates further forming of oxide

___ 18. To clean a soldering copper so the solder will then adhere to the copper, you can use--
A. muriatic acid
B. Sal ammoniac
C. rosin
D. hydrochloric acid

___ 19. For light-duty sheet metal products, you should use--
A. soldering gun
B. soldering copper
C. electric soldering iron
D. all of the above

___ 20. For soldering electrical components, use--
A. soldering gun
B. soldering copper
C. electric soldering iron
D. all of the above

___ 21. Sheet metal is seldom fastened with--
A. nuts and bolts
B. rivets
C. soldering
D. epoxy cement

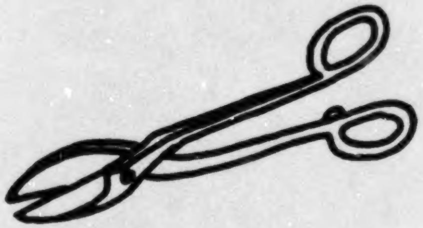
HANDOUT NO. 1

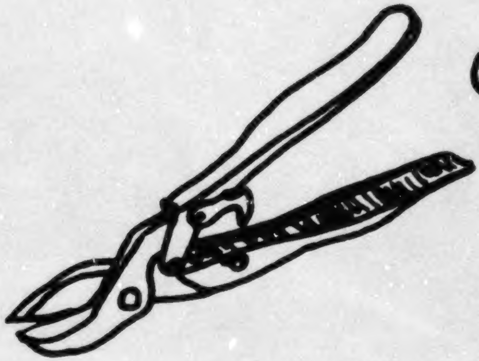
SIZES OF HOLLOW PUNCHES

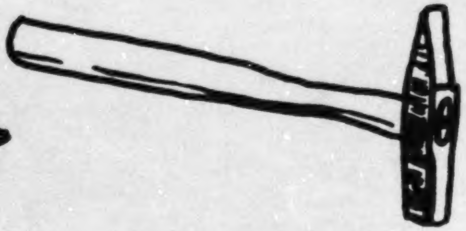
NUMBER	718	719	720	721	722	723	724	725	726
DIAMETER	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
NUMBER	727	728	729	730	731	732	733	734	735
DIAMETER	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8
NUMBER	736	737	738	739	740				
DIAMETER	2 1/2	2 5/8	2 3/4	2 7/8	3				

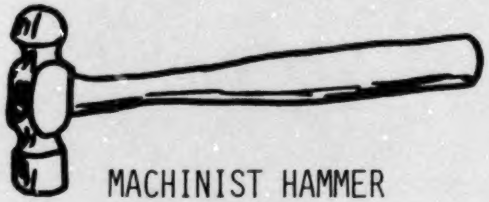
MW11-1

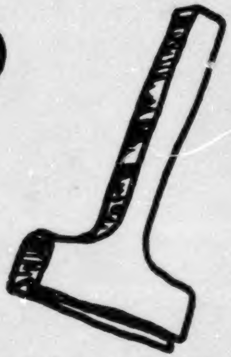
BASIC SHEET METAL HAND TOOLS

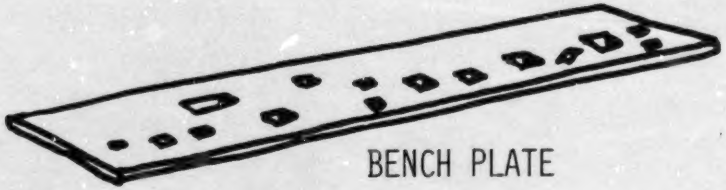

COMBINATION SNIPS


AVIATION SNIPS

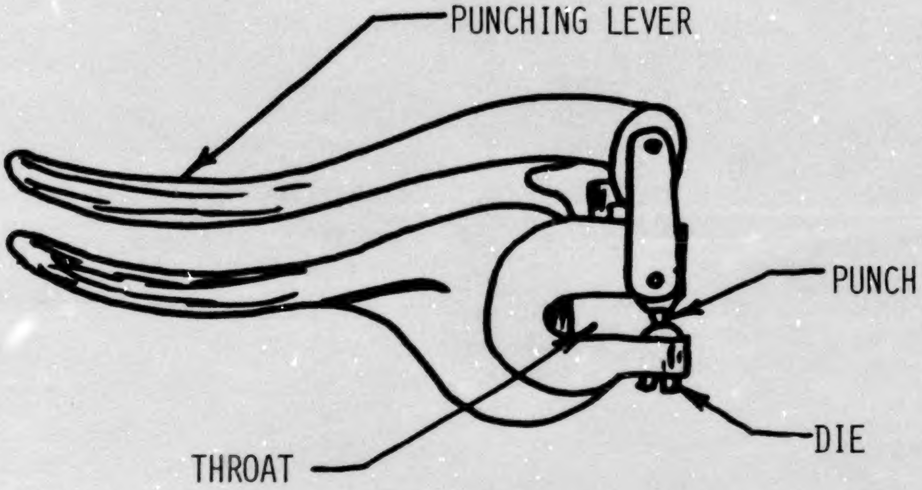

RIVETING HAMMER


MACHINIST HAMMER


GROOVING TOOL


BENCH PLATE

HAND PUNCH


PUNCHING LEVER
PUNCH
DIE
THROAT

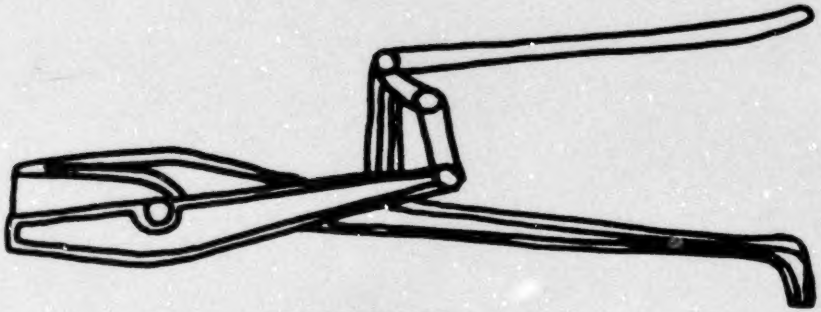
MW11-3

HOW TO USE THE HAND PUNCH

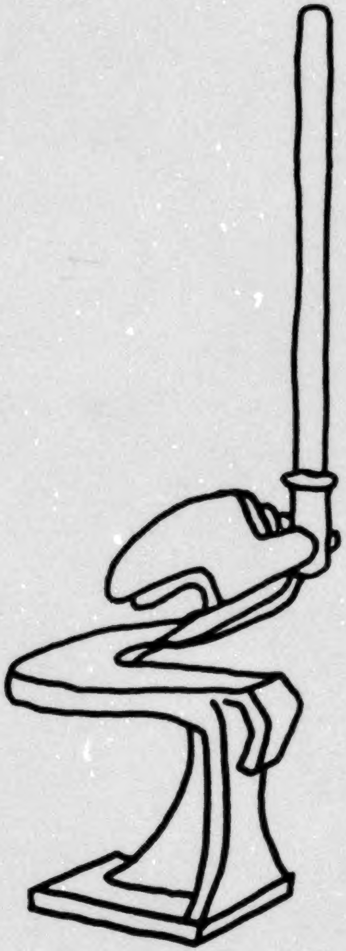
1. LAY OUT THE HOLES
2. MARK THE CENTERS WITH A PRICK PUNCH
3. LAY THE SHEET ON THE BENCH WITH THE MARKED HOLES EXTENDING BEYOND THE EDGE OF THE BENCH
4. PLACE THE CENTERING POINT OF THE PUNCH IN THE CENTER MARK ON THE SHEET
5. HOLD THE PUNCH IN A HORIZONTAL POSITION
6. PUNCH THE HOLE BY PRESSING THE UPPER LEVER DOWN

MW11-4

SHEARS

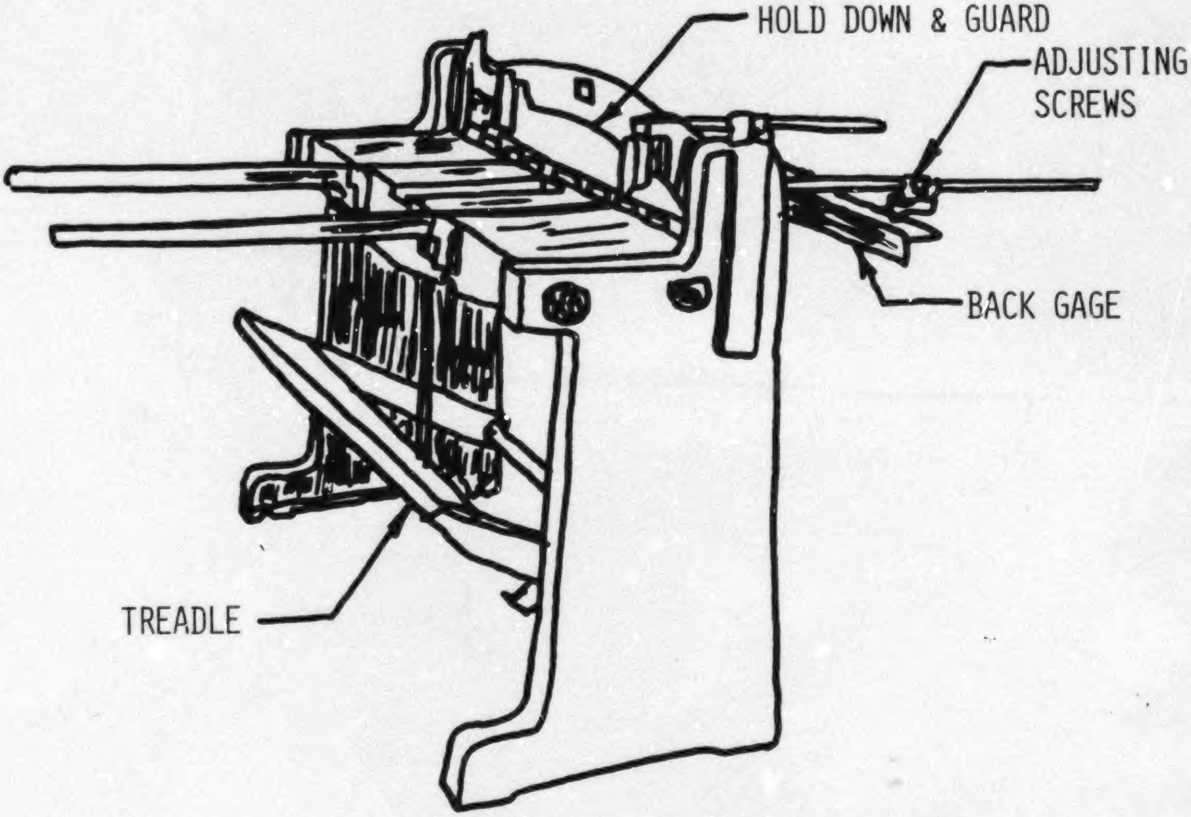


BENCH SHEAR

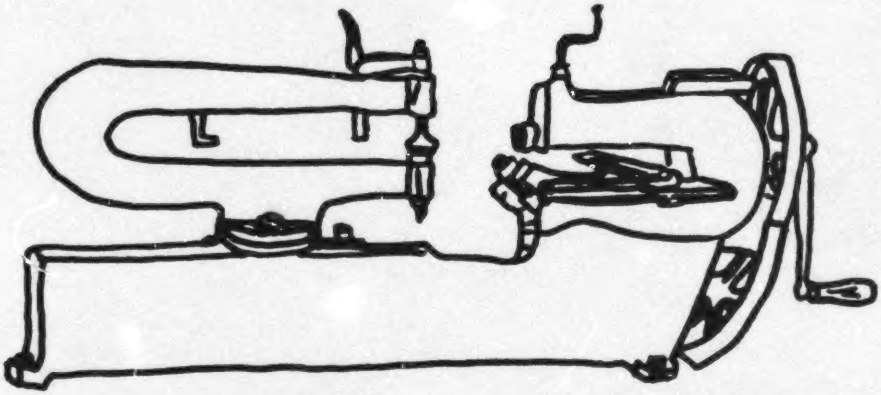


THROATLESS
HAND SHEAR

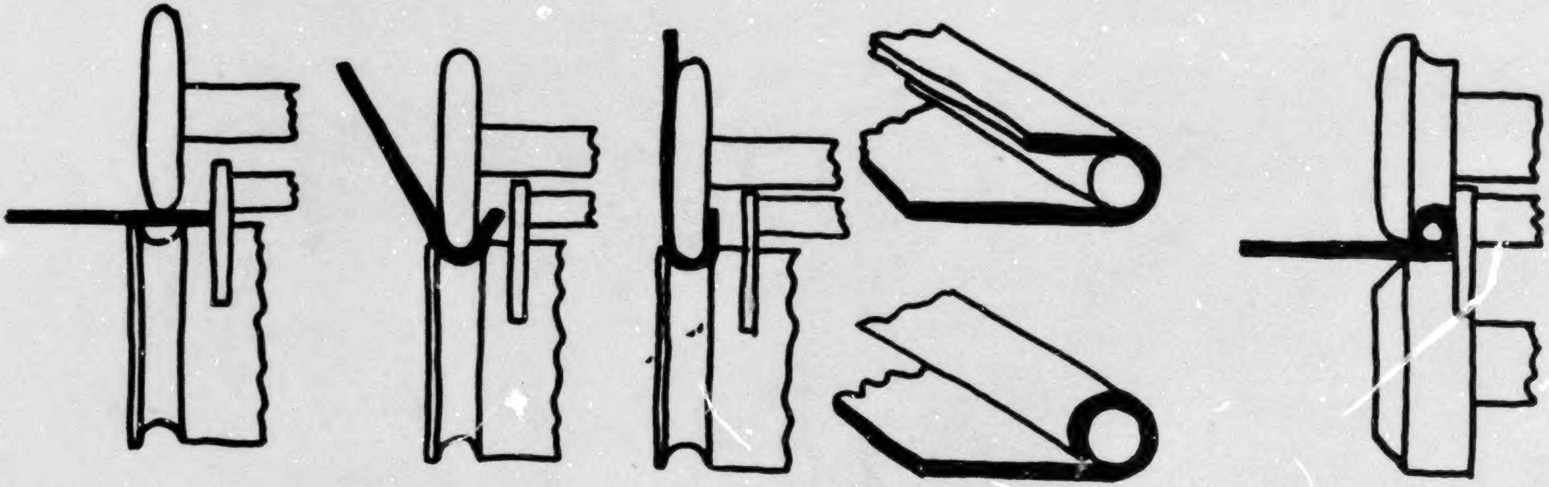
SQUARING SHEAR


HOLD DOWN & GUARD
ADJUSTING SCREWS
BACK GAGE
TREADLE

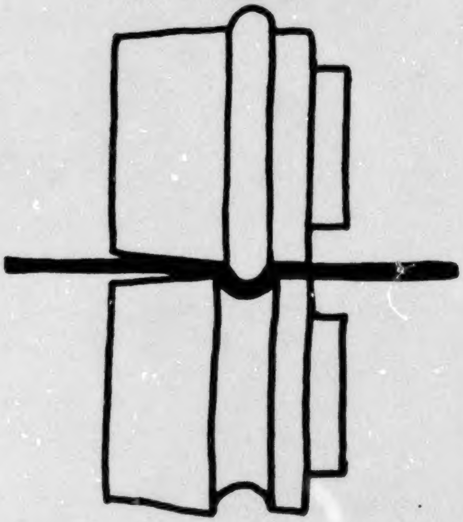
RING AND CIRCLE SHEAR



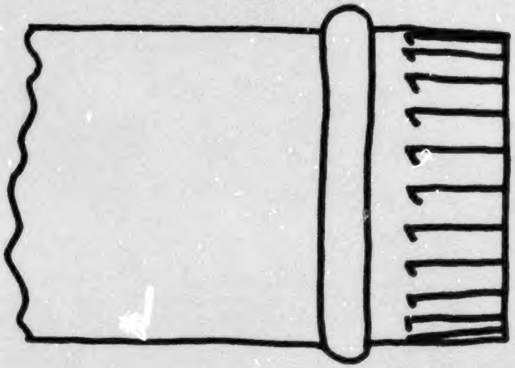
EXAMPLES OF FORMING OPERATIONS



TURNING AND CLOSING A WIRE EDGE

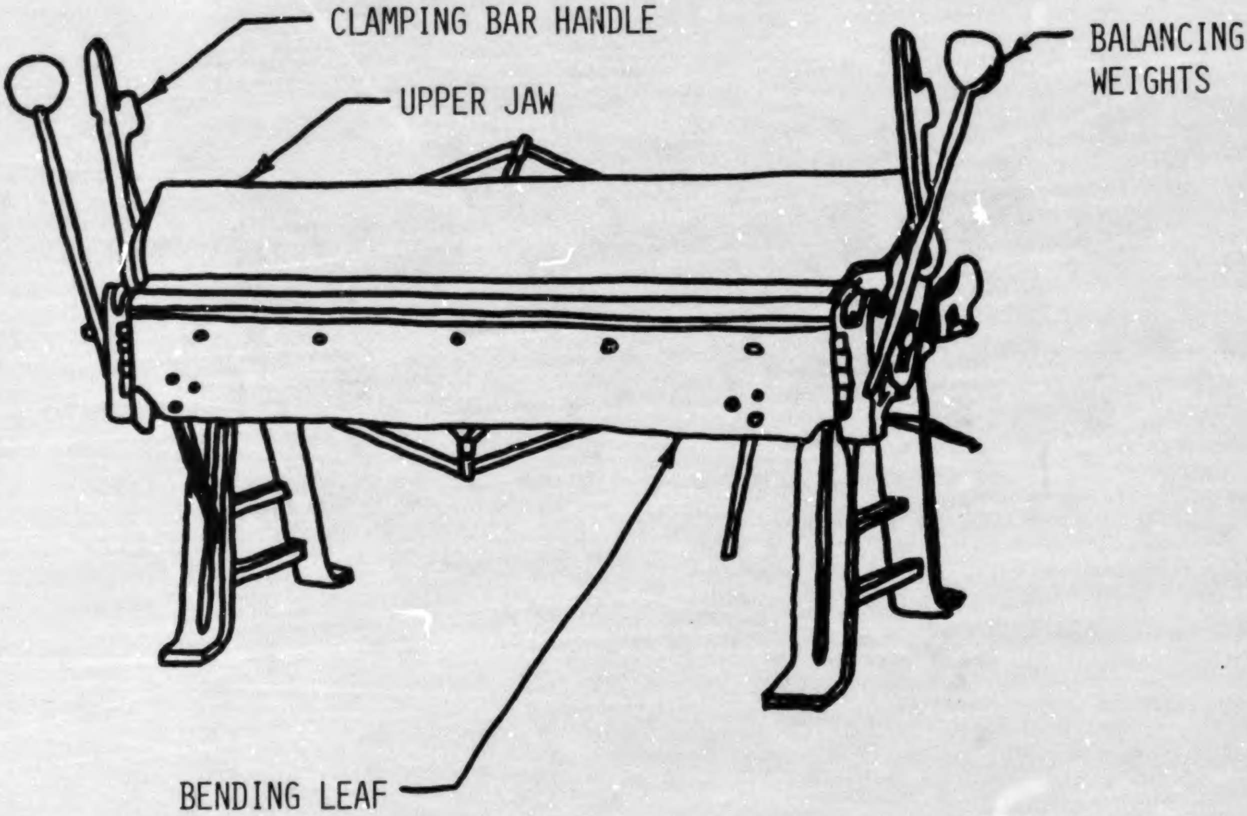


MAKING A BEAD

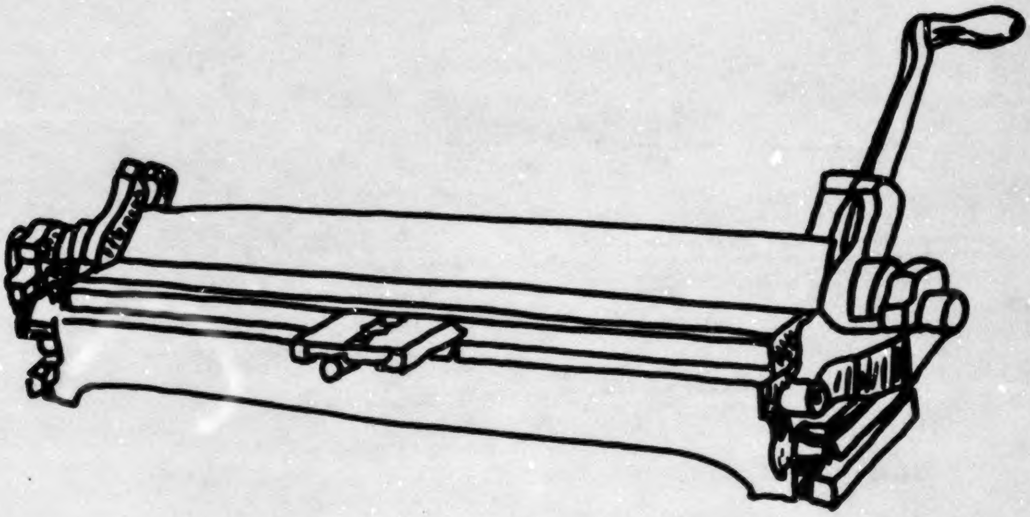


CRIMPING

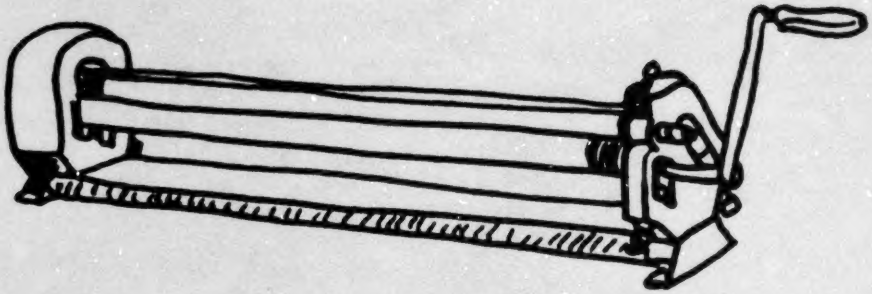
BRAKE


CLAMPING BAR HANDLE
UPPER JAW
BALANCING WEIGHTS
BENDING LEAF

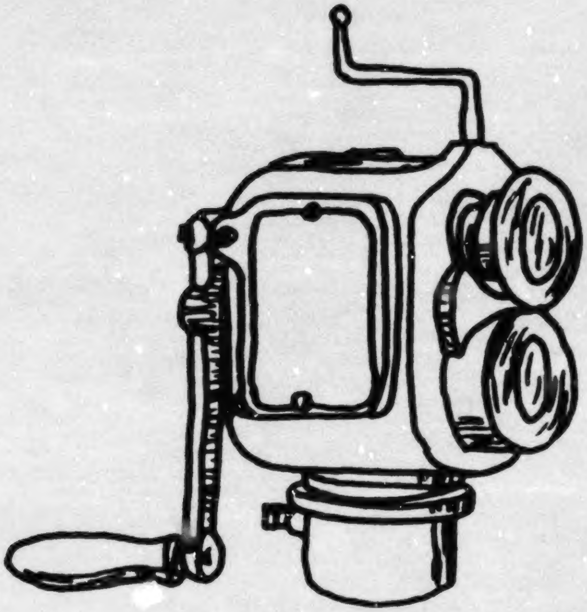
BAR FOLDER



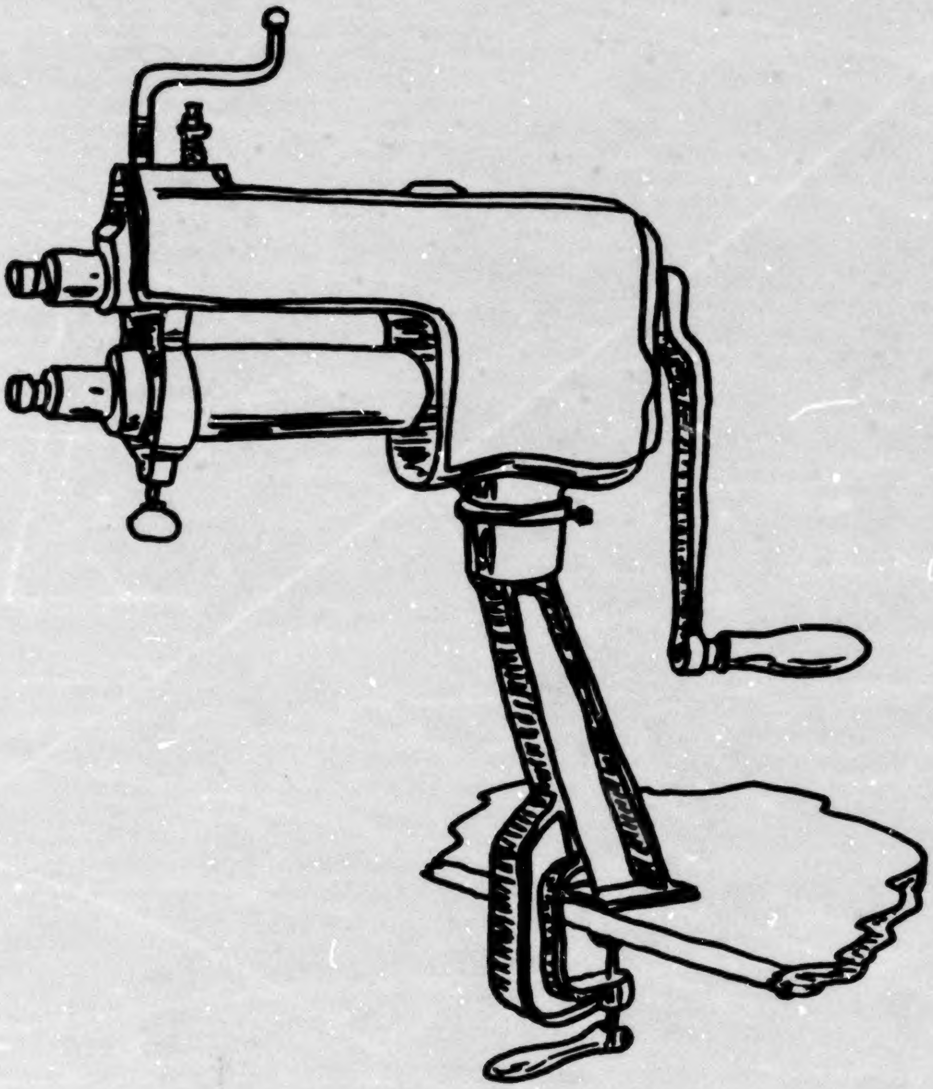
SLIP ROLL FORMING MACHINE



EASY EDGER
(COMBINATION ROTARY MACHINE)



ROTARY MACHINE



MW11-13

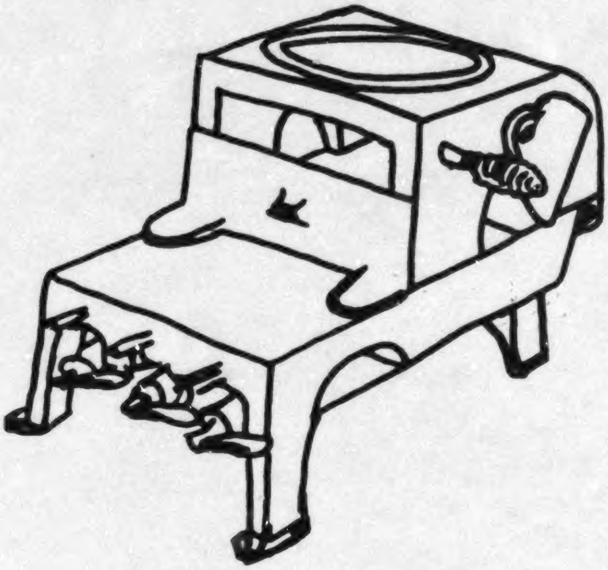
HOW TO HAND RIVET

1. SELECT RIVETS OF THE CORRECT TYPE, SIZE, AND MATERIAL
2. SELECT THE CORRECT RIVET SET
3. SELECT A RIVETING HAMMER
4. PLACE THE HEAD OF A RIVET ON THE SELECTED STAKE
5. PLACE THE PIECES TO BE RIVETED OVER THE RIVET
6. PLACE THE HOLE OF THE RIVET SET OVER THE RIVET
7. STRIKE THE TOP OF THE RIVET SET ONE OR TWO SHARP BLOWS
8. REMOVE THE RIVET SET
9. STRIKE THE TOP OF THE RIVET SEVERAL TIMES WITH THE FACE OF THE HAMMER
10. USE THE CUP-SHAPE HOLE OF THE RIVET SET OVER THE RIVET AND STRIKE THE RIVET SET ONE OR TWO SHARP HAMMER BLOWS

HOW TO FILE AND TIN A SOLDERING COPPER

1. SHUT OFF ALL VALVES OF THE GAS FURNACE
2. LIGHT THE GAS FURNACE
3. PLACE THE SOLDERING COPPER TO BE TINNED IN THE GAS FURNACE UNTIL IT IS HEATED TO A CHERRY RED
4. REMOVE THE SOLDERING COPPER FROM THE FURNACE AND CLAMP IN A VISE
5. FILE THE COPPER UNTIL THE SIDES ARE BRIGHT AND SMOOTH
6. REMOVE THE SOLDERING COPPER FROM THE VISE AND REHEAT JUST TO THE POINT WHERE IT WILL MELT THE SOLDER
7. REMOVE FROM THE FURNACE AND RUB EACH FILED SIDE BACK AND FORTH ACROSS A CAKE OF SAL AMMONIAC
8. ADD A LITTLE SOLDER TO THE SOLDERING COPPER AND THE SAL AMMONIAC

GAS-FIRED BENCH FURNACE



12

Career Opportunities

OBJECTIVES

After students have covered the material in this unit, they should be able to—

1. describe the world of work that will exist when they enter the employment market;
2. describe the process of career planning;
3. list several places where information can be obtained on a career in the metalworking industry;
4. list the factors that classify various metalworking careers;
5. state why it is important to graduate from high school;
6. list the various classifications of jobs in the metalworking industry;
7. describe the similarities and differences between a technician and a technologist; and
8. list various professional careers available in the metalworking industry.

KEY WORDS: VOCABULARY

The words listed below may be new to the student studying metalworking. Instructors should help students understand these words as they are used in this topic of study.

labor force
career planning
unskilled worker
semiskilled worker
skilled worker
technician
technologist
professional
manager
clerical worker
salesperson
on-the-job training

technical mathematics
apprenticeship program
independent judgment
community college
junior college
technical institute
statistics
cost estimates
technical reports
internship
business school

TEACHING AIDS

- Overhead projector
- Test Key: 1-C, 2-D, 3-A, 4-C, 5-A, 6-B, 7-C, 8-B, 9-C, 10-A

- Transparencies and Handouts: You will find transparency MW12-1 and Handouts No. 1 and No. 2 at the end of this unit. If you wish, these masters may be duplicated in quantity and given as handouts to students while they are studying different aspects of this unit.

  MW12-1: Employment & Compensation in U.S. Metalworking Industries—1981

  Handout No. 1: Application for Employment
  Handout No. 2: Comparison of Selected Metalworking Jobs

SUGGESTED REFERENCES

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SENTENCE OUTLINE

I. The age of technology
   - A. We are no longer an industrial society; we are in the age of technology.
   - B. Technology has resulted in new products such as microcircuitry, insulated clothing, dehydrated food, etc.
   - C. Professional and technological occupations are growing rapidly.
     1. Keeping up with technology will help you with possible job changes.
     2. Technology reduces the need for unskilled and semiskilled workers.

II. The metalworking industry
   - A. Iron and steel products represent the predominant metal of industrial societies. (Transparency MW12-1)
   - B. Imported steel is expected to remain a large factor.
   - C. Robotics
     1. Conservative estimates place the number of robots at work in U.S. industries at around 5,000.
     2. Over 100,000 robots are predicted to be in use in U.S. industries by 1990.
   - D. The labor force will grow at a 1.7% annual rate through 1987.
     1. Industrial progress makes many jobs obsolete and replaces them with new job titles.
     2. By 1987, over half the work force will be women.

III. Career planning
   - A. Career planning includes the processes of gathering information, comparing the information, considering alternatives, and pursuing a career goal.
   - B. Information on a metalworking career can be obtained from industrial technology instructors, guidance counselors, local colleges and/or universities, various employment agencies, trade unions, and federal agencies. (Handout No. 1)
   - C. Metalworking careers are classified according to required knowledge, skill, and length of training. (Handout No. 2)
     1. Employers want people with a good education plus a salable skill.

    2. People with specialized training and a good education will have a better chance to be hired and be promoted.
    3. Today's high school graduate will be employed in at least five different jobs during his or her lifetime—three of which do not currently exist.
    4. Persons who drop out of high school are not wanted in the metalworking industry.
  - D. One purpose of this class is to help you decide if you would like to work in the metalworking industry, at what level, and how to prepare for it.
  - E. The way you will live will depend on your career—so select it very carefully and prepare for it.

IV. Job classification: Jobs in the metalworking industry can be classified as (1) unskilled, (2) semiskilled, (3) skilled, (4) technician, (5) technologist, (6) professional, (7) management, (8) clerical, and (9) sales.

  - A. Unskilled workers have a very limited future since most are being replaced by automated machines.
    1. Unskilled workers do not have any special training.
    2. Unskilled laborers are steadily declining.
  - B. Semiskilled workers do routine work.
    1. Semiskilled workers do not have any formal education requirements.
    2. Most semiskilled workers work with their hands and require only a brief on-the-job training program.
    3. Semiskilled workers serve as helpers who assist skilled workers.
    4. Semiskilled workers assemble manufactured parts into complete units.
    5. Semiskilled workers operate machines or equipment.
    6. In addition to an hourly wage, some semiskilled workers are also paid according to the number of extra items they produce.
    7. Semiskilled workers include:
       - a. inspector
       - b. assembler
       - c. machine tool operator
       - d. mechanic
       - e. spot welder
       - f. painter
  - C. Skilled workers
    1. The skilled worker must have a good background in technical mathematics.
    2. The skilled worker acquires his or her skill through an apprenticeship program that varies from two to six years, or through an on-the-job training program.
    3. The skilled worker must continually update her/his skills.
    4. A skilled worker must know how to read and interpret drawings, use hand and machine tools, and use precision measuring equipment.
    5. Skilled workers make tools, machines, and equipment.
    6. The skilled worker is expected to exercise independent judgment.
    7. Skilled metalworkers include:
       - a. machinist
       - b. tool and die maker
       - c. instrument maker
       - d. setup person
       - e. molder
       - f. coremaker
       - g. welder
       - h. supervisor
       - i. pattern makers
       - j. jig and fixture maker
       - k. heat treatment specialist

D. Technicians are highly specialized and do complex work of a highly technical nature.
   1. The technician needs a strong background in math, science, and industrial technology.
   2. The technician should attend a community college, a junior college, or a technical institute.
   3. The technician programs the computer numerical control machines.
   4. The technician constructs and tests experimental devices and machines, compiles statistics, makes cost estimates, and prepares technical reports.
   5. The technician assists technologists and engineers in research, development, and designs.
   6. Technician careers include:
      a. technical report writer
      b. laboratory technician
      c. quality control assessor
      d. computer technician
      e. CNC planner and programmer

E. Professionals
   1. The technologist is a new professional category.
      a. The technologist, because of his/her place in industry, should have a basic understanding of mathematics, physics, chemistry, engineering, graphics, computer programming, business organization, and management.
         (1) A technologist must usually have four or more years of college, including a required internship.
         (2) The difference in educational training between a technician and a technologist is that a technician usually has a two-year degree while a technologist has a four-year degree.
      b. Technologists work in both the industrial laboratory and the engineering department.
         (1) The technologist supervises technicians.
         (2) The technologist does the applied engineering work.
            (a) The technologist does on-site surveys, laboratory experiments, and mathematical computations and oversees design studies.
            (b) Several technologists are employed for every engineer hired.
         (3) Some technologists and engineers advance to their position from a technician.
      c. Technologist careers include department head, personnel manager, training director, technical writer, labor relations director, production manager, product designer, quality control specialist, facilities planner, and cost estimator.
   2. Professional careers also include industrial technology teacher and various engineers.
      a. Professional occupations usually require four or more years of college.
      b. Engineers plan, design, and direct the operation.
      c. Engineers have an in-depth knowledge of mathematics, physics, and chemistry—and some understanding of drafting.

F. Management
   1. Management occupations usually require a four-year college education.
   2. Management directs and plans the work of others.
   3. Managers tell workers what jobs are to be done.
   4. Managers are responsible to be sure the job is done right and on time.
   5. Management occupations include:
      a. office manager
      b. labor relations manager

        c. personnel manager
        d. president
        e. vice-president
        f. general supervisor
        g. traffic supervisor
        h. material handling supervisor
        i. shipping supervisor

G. Clerical workers must have a high school education; a business school graduate is preferred.

H. Sales
    1. A college graduate is preferred for industrial sales since he/she can more easily deal with company management.
    2. Salespeople meet the public in everyday business transactions.

MATERIALS FOR STUDENTS

- Vocabulary worksheet
- Newspapers, magazines
- Drawing paper, pens, pencils
- Notebook (preferably a three-ring binder)

SUGGESTED STUDENT ACTIVITIES

1. Prepare a bulletin board on careers.
2. Invite a faculty member from a college/university to discuss the industrial technology teacher certification program.
3. Arrange for a field trip to an industrial plant to see the various occupations.
4. Ask students to make a list of careers available in metalworking, select one or two for further research, and report findings to the class.
5. Ask each student to select one type of metalworking industry and prepare a research report which includes history, number of people employed, products made, what the salaries and benefits are for various occupations, and whether it is a growing industry.
6. Have a representative from an industrial metalworking firm talk very candidly to your class about what it takes to be hired, to be promoted, and to be fired.
7. Review the cooperative education program at both the high school and college/university level.
8. Research the history of the International Association of Machinists.
9. Contact the American Industrial Arts Association for available software and literature on the teaching profession. Share with your students.
10. Show a film on the engineering profession.
11. Describe the members of an engineering team and how they interact.
12. Ask an individual from the State Employment Office to speak to your class about employment opportunities in the metalworking industry.
13. Discuss the advantages and disadvantages of going to a state employment agency versus going to a private employment service.
14. Ask students to bring in the want ads from different newspapers. Ask them to read the want ads and make a list of the jobs available in the metalworking industry. Analyze the jobs available as to whether they are unskilled, semiskilled, skilled, technical, or professional. Total the number in each category.
15. Develop a list of important questions that must be answered before pursuing a career.
16. Ask students to obtain a job application from a metalworking industry. Review the completing of an application.
17. Role-play a job interview.

Vocabulary Worksheet

1. labor force
2. career planning
3. unskilled worker
4. semiskilled worker
5. skilled worker
6. technician
7. technologist
8. professional
9. manager
10. clerical worker
11. salesperson
12. on-the-job training
13. technical mathematics
14. apprenticeship program
15. independent judgment
16. community college
17. junior college
18. technical institute
19. statistics
20. cost estimates
21. technical reports
22. internship
23. business school

TEST
UNIT 12: CAREER OPPORTUNITIES

Directions: Read each statement carefully. Select the one word, or phrase, that correctly answers or completes the statement. Write the appropriate letter in the blank.

Example: __D__ 21. The class you are in is--
A. Science
B. English
C. Art
D. Industrial Technology

___ 1. Technology reduces the need for which of the following metalworking industry job classifications?
A. skilled workers
B. technicians
C. semiskilled workers
D. technologists

___ 2. By 1987, approximately what percentage of the work force will be women?
A. 30%
B. 40%
C. 45%
D. 55%

___ 3. Which of the following is not considered when classifying metalworking careers?
A. sex
B. knowledge
C. skill
D. length of training

___ 4. Which of the following is not applicable to unskilled workers?
A. have a limited future
B. do not have any special training
C. are in demand
D. are being replaced with automated machines

___ 5. Which of the following is not applicable to semiskilled workers?
A. are only paid an hourly wage
B. most work with their hands
C. assemble manufactured parts into complete units
D. operate machines or equipment

___ 6. Which of the following is a skilled worker?
A. painter
B. machinist
C. mechanic
D. machine tool operator

___ 7. Which of the following is a technician?
A. welder
B. jig and fixture maker
C. CNC planner and programmer
D. heat treatment specialist

___ 8. Which of the following is a technologist?
A. machinist
B. facilities planner
C. CNC planner and programmer
D. assembler

___ 9. Which of the following is not a professional metalworking career?
A. engineer
B. technologist
C. technician
D. industrial technology teacher

___ 10. Which of the following is not true of management?
A. usually requires a two-year college education
B. directs and plans the work of others
C. tells workers what jobs are to be done
D. is responsible to be sure the job is done right and on time

HANDOUT NO. 1

APPLICATION FOR EMPLOYMENT

NAME ____________________ SOCIAL SECURITY NO. ____________

PRESENT ADDRESS ______________________________

HOW LONG HAVE YOU LIVED AT THE ABOVE ADDRESS? ____________

TELEPHONE NUMBER ____________ ARE YOU A CITIZEN? ____________

POSITION APPLIED FOR ______________________________

RATE OF COMPENSATION EXPECTED $ __________ PER YEAR

WERE YOU PREVIOUSLY EMPLOYED BY THIS COMPANY? ______ IF YES, WHEN ______

DO YOU HAVE ANY RELATIVES EMPLOYED BY THIS COMPANY? ______ IF YES, PLEASE LIST:

NAME ____________ ADDRESS ____________________

____

NAME ____________ ADDRESS ____________________

____

WHEN WILL YOU BE AVAILABLE FOR EMPLOYMENT? ____________________

EDUCATION RECORD

HIGH SCHOOL: YEARS ATTENDED ____________ DID YOU GRADUATE? ________

COLLEGE: YEARS ATTENDED ____________ DID YOU GRADUATE? ________

MILITARY SERVICE RECORD

ARE YOU A VETERAN? ______ ANY JOB-RELATED EXPERIENCE? ______ IF YES, PLEASE STATE TYPE: ______________________________

EMPLOYMENT RECORD

BEGIN WITH THE MOST RECENT, AND LIST ALL PRESENT AND FORMER EMPLOYMENT FOR THE PREVIOUS TEN YEARS:

COMPANY ____________ DATES EMPLOYED ____________

SALARY ________ TYPE OF WORK ____________________

COMPANY ____________ DATES EMPLOYED ____________

SALARY ________ TYPE OF WORK ____________________

COMPANY ____________ DATES EMPLOYED ____________

SALARY ________ TYPE OF WORK ____________________

(USE BACK OF SHEET FOR ADDITIONAL INFORMATION)

PERSONAL REFERENCES (INCLUDE NAME, ADDRESS, PHONE NUMBER)

____

____

____

HANDOUT NO. 2

COMPARISON OF SELECTED METALWORKING JOBS

JOB	WAGES	KIND OF WORK	HOURS	TRAINING REQUIRED	DANGERS INVOLVED	WHERE CAN IT BE LEARNED

MW12-1

EMPLOYMENT & COMPENSATION
IN U.S. METALWORKING INDUSTRIES - 1981

	PERSONS ENGAGED IN PRODUCTION (IN THOUSANDS)	AVERAGE COMPENSATION PER EMPLOYEE (PER YEAR)
ALL PRIVATE INDUSTRIES	79,269	$20,304
MANUFACTURING INDUSTRIES	20,032	24,296
DURABLE GOODS INDUSTRIES	12,139	25,911
PRIMARY METAL INDUSTRIES	1,113	32,672
FABRICATED METAL PRODUCTS	1,567	24,305